Development of a Taxonomy of Human Performance:

A Feasibility Study of Ability Dimensions for Classifying Human Tasks

George C. Theologus
Tania Romashko
Edwin A. Fleishman

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DEVELOPMENT OF A TAXONOMY OF HUMAN PERFORMANCE: A FEASIBILITY STUDY OF ABILITY DIMENSIONS FOR CLASSIFYING HUMAN TASKS

George C. Theologus
Tania Romashko
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ABSTRACT

A major problem which confronts the behavioral sciences is the lack of a unifying set of dimensions for describing human task performance. The absence of such a system limits the ability to relate human performance observed in one task to that observed in similar tasks. There is a need for a well-defined task-descriptive language for use by those who must apply the results of research to operational tasks. This report describes one of several approaches under development as part of a larger program; the approach is concerned with developing a task classification system based upon known parameters of human performance. The human abilities, upon which this system was based, were derived primarily from the reported factor analyses of human performance in the cognitive, psychomotor, physical, perceptual, and sensory areas. Definitions of the abilities were developed together with rating scales for each ability. A series of pilot studies then were undertaken with the objective of producing an instrument which would have high reliability in classifying human tasks. During these exploratory studies, the initial set of human abilities was modified, the definitions of the abilities were revised, and the rating technique was improved upon. In addition, the studies examined various methods of analyzing the reliability data, and compared two methods of anchoring the rating scales. The results of this pilot research indicated that it was possible to develop a set of reliable, ability-based scales for classifying tasks, although more work will be needed. Future research on a human ability approach to classification will continue with the investigation of the problems of scale reliability and will initiate research on questions of the validity of the classificatory instrument.

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INTRODUCTION

A major problem which confronts the behavioral sciences is the lack of a unifying set of dimensions for describing human task performance. The absence of such a system limits the ability to relate human performance observed in one task to that observed in similar tasks. At present, research results obtained with one task can safely be generalized only to tasks which are so highly similar as to be almost identical; beyond this, generalization becomes imprecise and, in some instances, risky. The ability to communicate research findings is likewise limited. Behavioral scientists, and those who must apply research findings to operational problems are without a well-defined task descriptive language to use in reporting and interpreting research results.

As more and more research is conducted and the available research literature grows, the need increases for a system for classifying human tasks which would permit dependable predictions of the effects of independent variables on task performance within and between classes of tasks. The need is especially great for making most effective use of available data and for predicting performance on new tasks. There is a need for a set of unifying task dimensions for bridging the gap between laboratory research and those human factors, training, and design specialists who must apply these findings. This need has been sufficiently documented by Fitts (1962), Fleishman (1962, 1967), Melton and Briggs (1960), and Miller (1962).

One approach to developing such a system lies in the use of known parameters of human performance as a basis for describing and classifying tasks. A major source of information comes from the literature on human abilities identification. This extensive research has been

based on empirically derived intercorrelations among task performances in a variety of performance areas (e.g., cognitive, psychomotor, etc.). Yet, this information has never been tested for its utility in describing tasks used in the experimental literature on factors affecting human performance.

The description of tasks in terms of the types and amounts of human abilities required for task performance could produce a classification system within which it is possible to predict the effects of independent variables in situations where these effects have not been experimentally measured. Such predictions would be based upon knowledge of the effects of independent variables on the performance of tasks requiring particular human abilities. Thus, research results might be generalized between task situations on the basis of the degree of similarity among the ability requirement profiles of the tasks involved.

The present report describes a series of studies carried out to develop methods by means of which observers can describe tasks in terms of their ability requirements. The general objective was to provide an instrument which could be utilized to describe both laboratory and operational tasks along a comprehensive set of specifically defined ability dimensions.

BACKGROUND AND OBJECTIVES

The present study is part of a larger program concerned with developing a classification system for human tasks (Fleishman, 1967; Fleishman, Kinkade, & Chambers, 1968; Chambers, 1969: Farina, 1969; Theologus, 1969; Wheaton, 1969). One purpose of this effort is to determine whether the classification of tasks allows for increased generalization of experimental data within and among classes of tasks. As part of this general program, several provisional classification systems are being developed. The present report describes the development of one of these systems which seeks to employ human abilities as task descriptors in order to be able to relate tasks on the basis of the salient behaviors required for task performance.

Origin of the Abilities Approach to Classification

An examination of the literature revealed that several classification systems have been developed which could possibly serve as bases for the present effort; these systems were carefully reviewed and are reported elsewhere (Farina, 1969; Theologus, 1969; Wheaton, 1969). While these reviews provided some guidance to the present effort, many of the past classificatory attempts were considered inappropriate for the present purposes since they were not directly related to the prediction of human task performance. For example, some systems are primarily directed toward job analysis, where, according to Farina (1969), the basic unit of study deals with a unit larger than a task (e.g., the job or the totality of tasks, duties, and responsibilities).

Other sources of difficulty arise in the lack of operational task definitions. For example, task categories like

vigilance, monitoring, scanning, or watch-keeping may or may not represent the same category, from one system to the next; it is often difficult to tell since the task behaviors are not always sufficiently specified.

Of the remaining systems, most were either based on categories which were too broad (e.g., "decision-making", "problem-solving") or too narrow (e.g., "rotates control knob"). Past experience in classification indicates that such descriptors do not allow for dependable prediction of human performance. The reason may be that such descriptors bear little relationship to what has been experimentally established regarding human performance. The descriptors ignore our present knowledge as to the nature and number of human performance categories. Present knowledge would indicate that broad categories such as "problem-solving" or "perceptual-motor" are not unitary processes and that highly specific categories such as "rotates knob" are not general types of human performance. Thus, there is reason to doubt that systems based on categories such as these will be successful in allowing dependable predictions of human performance from one task to another.

For example, the broad category of "perceptual-motor" is likely to be relatively useless in generalizing from one "perceptual-motor" task to the next. Knowledge from research on correlations among human performances indicates a greater degree of specificity than this and a considerable diversity of function within this category (see Fleishman, 1964). "Manual Dexterity", "Multilimb Coordination", and "Control Precision" are a few examples of the many perceptual-motor abilities which have been experimentally shown to underlie the broad category of "perceptual-motor". Not only have such abilities been identified, but they also have been found to be related to performance in a variety of human tasks. For example, "Spatial-Visualization"

has been shown to account for performance in such diverse tasks as aerial navigation, blueprint reading, and dentistry. Put in other terms, each of these tasks is, in part, describable in terms of that component of its performance which can be attributed to the ability of "Spatial-Visualization". Thus, in choosing a level and basis for task description in terms of human performance, it would appear wise to capitalize upon the experimental knowledge we already possess concerning basic human abilities.

Derivation of Human Abilities

In order to more fully understand the use of human abilities in task classification, it may be useful to describe some of the logic and technique for their derivation (see Fleishman, 1967). Generally, in establishing a set of abilities, a sub-area of human performance is studied where tasks are specifically designed to tap certain hypothesized ability categories. These tasks are administered to samples of subjects and the correlations among them are obtained and subjected to factor analytic study. Based on this information, additional hypotheses are generated and further studies are conducted to sharpen the definitions of the categories. Many of these later studies introduce variations in the tasks to investigate the relationships between the task parameters (e.g., number or nature of stimuli) and the ability requirements. This is done through an examination of correlations between performance on reference measures and performance on tasks whose parameters have been varied. The purpose of this procedure is to define the fewest independent ability categories which might be most useful and meaningful in describing performance in a wide variety of tasks.

It is perhaps not too extreme to state that most of the categorization of human skills, which is empirically based, comes from such correlational and factor analytic studies. We can think of such

categories as representing empirically derived patterns of response consistencies to task requirements varied in systematic ways. In a sense, this approach describes tasks in terms of the common abilities required to perform them. The fact that individuals who do well on task A also do well on tasks B and C but not on tasks D, E, and F indicates, inferentially, a common process involved in performing the first three tasks distinct from the processes involved in the latter three. To account for the observed consistencies an ability is postulated. Once postulated in this fashion, the definition of the ability must then be refined and its limits carefully specified by further research.

The result of this careful experimental process is a set of abilities which vary in scope and specificity. However, they all provide insights into the nature of human performance. For example, it is important to know that it is not too useful to talk about "strength" as a performance dimension. In terms of what tasks the same people can do well, it is more useful to talk in terms of at least three general strength categories (Dynamic Strength, Static Strength, and Explosive Strength) which may be differentially involved in a variety of physical tasks (see Fleishman, 1964).

Purpose of the Present Research

Substantial experimental effort has been devoted to the identification of the basic human abilities, although the work is not complete in all areas of human performance. The result has been the establishment of sets of abilities encompassing much of the cognitive, perceptual, psychomotor, and physical areas of performance. Because these major areas of human performance have already been delineated in terms of ability dimensions, a significant step has been taken toward

the adequate coverage of the entire range of human abilities which may be required for performance on any type of task. Thus, abilities provide a natural basis for describing and hence classifying tasks in terms of human performance requirements. Some evidence already exists that a classification system thus developed helps to integrate a wide range of behavioral data and phenomena (Fleishman, 1967). However, we do not yet know the extent to which the use of such ability categories in describing tasks facilitates the generalization of research results on the effects of various independent variables on human performance. We also do not know the extent to which these categories can be used reliably by human factors technologists, behavioral scientists, and other specialists in describing human tasks.

Before the first of the above problems can be approached, it is necessary to deal with the second. To examine the second problem a prototypical instrument for classifying tasks on the basis of ability requirements was developed. Both this instrument and a modified version of it were then employed in a series of feasibility studies designed to provide an initial assessment of the reliability of the instrument and to uncover any areas which would merit further development or revision. This paper reports on these activities.

DEVELOPMENT OF ABILITY DIMENSIONS

The present research effort was designed to accomplish three limited objectives. First, a set of Task Assessment Scales (TAS) on which tasks could be rated on ability dimensions was to be developed. Second, to aid in future research with the TAS, statistical techniques for analyzing the data were to be examined and evaluated. Third, a preliminary determination was to be made as to whether judges could agree on the rating of tasks by means of the TAS.

Development of the TAS

Generation of ability lists. The first step in the development of the TAS was the derivation of a list of abilities upon which tasks could be rated. In addition, each of these abilities had to be defined so that it could be unambiguously communicated to a panel of judges. In order to derive such a list of abilities, a literature review was conducted to determine the cognitive, perceptual, and psychomotor ability factors which have been identified in rather extensive factor-analytic studies.

For the cognitive and perceptual domains the primary sources of reference were Guilford's work (1967) on the nature of the intellect, and French's work (1951, 1963) on cognitive and perceptual reference tests and factors.

From these sources, a set of 19 abilities was selected based upon the criterion that each ability was identified in a minimum of ten individual studies. A definition for each of these 19 abilities was developed by integrating French's definition for a given ability with Guilford's definition of the equivalent ability. Included in each definition were examples of tests which possessed the highest loadings

on each factor. This step permitted further specifications of the 19 definitions.

With respect to the psychomotor area, a set of abilities was selected from those factors analytically established by Fleishman (e.g., Fleishman, 1954, 1958, 1960, 1962). The definitions employed for these abilities were essentially those provided by Fleishman. Again, as in the cognitive and perceptual areas, representative tasks were included as examples with each definition.

These psychomotor abilities were merged into a single list with the cognitive and perceptual abilities and this preliminary list was reviewed by AIR personnel for their comments. A series of interviews and discussions among members of the staff revealed a number of areas that merited further consideration. These included: a) the need for a more comprehensive ability list; b) the need to clarify vague and ambiguous definitions; and c) the need to provide additional examples. In response to these comments, several actions were taken. The preliminary abilities list was expanded to incorporate sensory and physical proficiency abilities. These latter abilities were derived from work by Fleishman (e.g., Fleishman, 1963, 1964). Second, an attempt was made to carefully delineate the extent and limits of each ability in the list. Third, additional examples were included in the ability definitions to better illustrate the abilities.

In still another effort to sharpen the abilities list, a variety of experimental studies was reviewed in order to determine whether any obvious areas of performance were not represented in the ability list. From this review it became apparent that the list was still incomplete since some task elements could not be analyzed in terms of the existing ability list. Recognition of this fact led to the inclusion

of a group of abilities which have not been studied to any great extent, but which, nevertheless, appear to have wide applicability to human performance (e. g., time-sharing and attention). The result of these efforts was a list of 49 abilities with definitions and examples for each (Table 1, Appendix A).

In addition to this list of specific abilities, a list of 12 general abilities was constructed (Table 2, Appendix A). The purpose of this second list was to determine whether a wide variety of tasks could be effectively analyzed using fewer but broader ability categories. This list was developed by collapsing many of the similar specific abilities into more general descriptors. For instance, Associative Memory-Meaningful Pairings and Associative Memory-Arbitrary Pairings were collapsed into the single category of Memory.

Selection of task descriptions. In order to further refine the two ability lists, a sample of judges next rated a set of task descriptions, utilizing rating scales. For each ability, the rater was required to rate the degree to which that ability was required by that task. The task descriptions were obtained from a review of experimental journals and technical reports.

The task selection process was based upon several criteria: (1) completeness of task descriptions, (2) range of behaviors sampled, and (3) a balance between "real world" and laboratory tasks. A rough categorization of the set of task descriptions produced by this literature search is shown in Table 1. The three "real world" tasks employed a task analysis format in which the task procedures were presented in a step-by-step fashion. The three laboratory tasks were described in paragraphs which included information on subjects, apparatuses and procedures.

TABLE 1

Task Descriptions Employed in Developing
Preliminary Form of the TAS

Task Title	Type	Performance Category
Computer programmer	Real world	Cognitive
Fire control leader	Real world	Cognitive/Psychomotor
Sheet metal worker	Real world	Psychomotor
Problem similarity	Laboratory	Cognitive
Letter recognition	Laboratory	Cognitive/Psychomotor
Polar pursuit	Laboratory	Psychomotor

Test of original TAS. To rate the task descriptions on the ability scales a sample of 18 professional personnel from the American Institutes for Research in Washington, D. C. were selected to serve as judges. The 18 individuals were randomly assigned to one of two groups. The members of one group received the general ability list (12 descriptors) while the members of the other group received the specific ability list (49 descriptors). Each judge also received the set of six task descriptions and six scoring forms on which to rate each of the tasks. The 18 AIR judges rated each of the six tasks on each of the abilities in the list which they had been assigned. The ratings were made by first scoring an ability as present or absent in a given task and then, for those abilities rated as present, by determining whether the ability was "critical" if it contributed to individual differences in performance. Although these data were analyzed, of primary importance were the opinions of the judges concerning the adequacy and comprehensiveness of the scales. To obtain these opinions two steps were taken. First, each judge was asked

to make written notes as he attempted to employ the scales. In addition, each judge was interviewed and his verbal comments and impressions were obtained.

In general, the results of this small scale examination of the TAS, coupled with the judges' comments, indicated that the abilities approach to task classification was feasible. A comparison of the data obtained from the application of the two ability lists showed that the specific list (49 abilities) allowed for a more detailed and thorough analysis of the task descriptions without any loss in inter-judge agreement. This finding was reinforced by the verbal and written comments of the judges.

Further analysis of the judges' comments revealed two additional areas which deserved consideration:

1. the need to modify the specific ability definitions so as to reduce apparent overlap among them, and
2. the need to modify memory abilities since they appeared to inadequately represent the memory area.

Revision of the TAS[1]

Based upon the comments and the data discussed above, the general ability list was eliminated from further consideration, and it was decided to focus future efforts on the specific list. However, based on the judges' comments, several changes were made in the specific list. First, the definitions of those abilities, which were most often confused with other abilities, were revised so as to emphasize the extent and limit of each ability. During this revision,

[1] The revised TAS can be found in Appendix B.

care was taken to stress the distinctions among abilities. In addition, when an ability's label (or name) was noted by the judges as being confusing with respect to its definition, the label was changed to better represent the definition.

Second, the original ability list contained only two memory abilities which the judges felt were inadequate for rating tasks in which a memory function was required. In order to revise and expand the memory area, a literature review of memory studies (e.g., Christal, 1968; Kelley, 1964; Guilford, 1967) was conducted. This review yielded five memory functions which were felt to be logically distinct.

Third, the instructions originally given to the 18 AIR judges were singled out for attention, since they were considered to be too general in nature. In an attempt to remedy this situation, a detailed explanation of the abilities approach to classification was developed. Major sections included in this explanation were: (1) a background and rationale for the approach, (2) a description of the materials to be used, and (3) a schema for applying the abilities to tasks as well as criteria for their application. These more detailed instructions were incorporated into the revision of the TAS.

FIRST PILOT STUDY

Design

Once the TAS had been revised, a pilot study was designed to reassess the TAS, to evaluate statistical methods for analyzing the data, and to determine, in a preliminary fashion, whether the judges could agree on the rating of the abilities required for performance on a given task.

A set of six tasks was selected for the pilot study. These tasks are listed in Table 2, and the complete task descriptions can be found in Appendix B. Three of these tasks (sheet metal worker, polar pursuit, and letter recognition) were the same as those used in the exploratory effort, described above, to refine the TAS. Three new tasks (astronaut, air traffic controller, and helicopter pilot) were chosen to maintain the balance between "real world" and laboratory tasks.

TABLE 2

Task Descriptions Used in the Pilot Study

Task Title	Type	Performance Category
Sheet metal worker	Real world	Psychomotor
Air traffic controller	Real world	Cognitive
Helicopter pilot	Real world	Cognitive/Psychomotor
Polar pursuit	Laboratory	Psychomotor
Letter recognition	Laboratory	Cognitive
Astronaut	Laboratory	Cognitive/Psychomotor

The subjects selected for the pilot study consisted of 25 judges from AIR and 60 judges from outside AIR. The outside judges were chosen from the membership of the Division of Evaluation and Measurement (Division 5) of the American Psychological Association (APA). Each of the APA judges was a well-known expert in the field of psychological measurement. Of these 60 judges, 32 completed and returned the kits which were mailed to them.

Each of the AIR judges received a kit consisting of the TAS and a set of six task descriptions, to be assessed in the order in which they were presented. This order of presentation was randomized. The APA judges received a similar kit except that the number of task descriptions was reduced to three in order to lighten the work-load and thereby increase the number of returns. The assessment of the full set of six task descriptions required approximately five hours. The judges were required to rate each of the tasks on each of the abilities as "Not Involved", "Base-line", or "Critical". "Base-line" was defined as the amount of the ability that an average person would exhibit. "Critical" was defined as being above base-line; that is, the average person would not exhibit the amount of the ability required.

Analysis and Results

The data derived from the pilot study were analyzed by means of intraclass correlation coefficients (r_{kk}) (Winer, 1962, p. 126) and percentage distributions of the judges' ratings to determine inter-judge reliability on specific ability scales, and by means of similarity coefficients (r_p) (Cattell & Coulter, 1966) to determine the similarity between pairs of task ability profiles.

In computing the r_k values for each ability, the judges were treated as three groups: (1) the AIR judges (n = 25) who rated all six tasks, (2) the APA judges (n = 16) who rated tasks 1, 2, and 4, and (3) the APA judges (n = 16) who rated tasks 3, 5, and 6. In addition to the r_k values, the derived coefficients for the reliability of a group of five judges (r_5) and for the reliability of a single judge (r_1) were also calculated. Both r_5 and r_1 are relevant to this study since they bear on the future use of the TAS. If the TAS is to be employed by groups of judges, then r_5 would be an appropriate reliability estimate. If the TAS is to be used by a single judge, then r_1 would be appropriate.

The r_k data are shown in Table 3 and the r_5 and r_1 data are shown in Table 4. In general, these data reveal that a large number of the scales show high reliabilities when large groups of raters are used but that they cannot be employed reliably either by small groups of five judges (r_5) or by individual judges (r_1). Only Ability 26, Control Precision, showed any consistent reliability across all three groups of judges.

To obtain insight into the exact nature of the reliabilities reflected by the r_k's, the distributions of the judges' ratings of each task, on each ability, were examined by calculating the percentage of judges who rated the task as a "zero", "one", or "two". For the purposes of this analysis, "agreement" was arbitrarily defined as 80% or more of the judges rating a given task, on a given ability, in exactly the same fashion. This is admittedly a stringent criterion, but it is felt that this is necessary if the scales are to be used in later phases of the research program.

TABLE 3

Reliabilities (r_k) for the Three
Groups of Judges on Each Ability Scale

ABILITY	AIR Judges (Tasks 1 to 6) r_{25}	APA Judges (Tasks 1,2, 4) r_{16}	APA Judges Tasks 3, 5, 6) r_{16}
1. Verbal Comprehension	.71	.67	.74
2. Associational Fluency	.00	.69	.47
3. Word Fluency	.30	.67	.49
4. Serial Recall	.69	.92	.79
5. Free Recall	.79	.82	.84
6. Paired Associate Memory	.92	.88	.90
7. Memory for Operations	.89	.93	.73
8. Memory for Ideas	.75	.86	.88
9. Symbolic and Semantic Ordering	.87	.85	.78
10. Ideational Fluency	.41	.00	.49
11. Originality	.65	.22	1.00
12. Category Flexibility	.00	.38	.78
13. Induction	.79	.68	.69
14. Syllogistic Reasoning	.88	.65	.18
15. Arithmetic Reasoning	.94	.93	.84
16. Number Facility	.89	.96	.24
17. Problem Sensitivity	.96	.93	.95
18. Flexibility of Closure	.91	.75	.95
19. Perceptual Speed	.77	.00	.89
20. Spatial Orientation	.95	.87	.95
21. Spatial Scanning	.93	.93	.92
22. Visualization	.91	.95	.88
23. Auditory Perceptual Speed	.91	.76	.89
24. Auditory Rhythm Discrimination	.81	.00	.88
25. Arm-Hand Steadiness	.93	.97	.92
26. Control Precision	.98	.98	.98
27. Finger Dexterity	.91	.77	.88
28. Manual Dexterity	.95	.91	.92
29. Multilimb Coordination	.98	.00	.97
30. Rate Control	.97	.95	.94
31. Reaction Time	.82	.69	.93
32. Speed of Arm Movement	.72	.92	.66
33. Response Orientation	.90	.07	.93
34. Wrist-Finger Speed	.67	.67	.00
35. Verbal Expression	.95	.98	.78
36. Attention	.87	.16	.88
37. Time Sharing	.95	.88	.97
38. Explosive Strength	.73	.00	.19
39. Static Strength	.94	.00	.84
40. Dynamic Strength	.85	.00	.75
41. Extent Flexibility	.82	.00	.84
42. Dynamic Flexibility	.73	.00	.90
43. Gross Body Equilibrium	.87	.00	.93
44. Gross Body Coordination	.82	.00	.89
45. Stamina	.69	.68	.78
46. Depth Perception	.94	.00	.99
47. Color Discrimination	.91	.00	.97
48. Near Visual Acuity	.30	.00	.00
49. Far Visual Acuity	.97	.68	.98
50. Kinesthetic Discrimination	.94	.52	.91

TABLE 4

Group (r_5) and Individual (r_1) Reliabilities
For Each Ability Scale

ABILITY	AIR Judges (Tasks 1 to 6)		APA Judges (Tasks 1,2,4)		APA Judges (Tasks 3,5,6)	
	r_5	r_1	r_5	r_1	r_5	r_1
1. Verbal Comprehension	.33	.09	.39	.11	.47	.15
2. Associational Fluency	.00	.00	.41	.12	.21	.05
3. Word Fluency	.08	.02	.39	.11	.23	.06
4. Serial Recall	.31	.08	.77	.40	.54	.19
5. Free Recall	.43	.13	.58	.22	.62	.25
6. Paired Associate Memory	.70	.32	.70	.32	.73	.35
7. Memory for Operations	.62	.25	.81	.46	.46	.15
8. Memory for Ideas	.37	.11	.66	.28	.69	.31
9. Symbolic and Semantic Ordering	.57	.21	.63	.27	.53	.18
10. Ideational Fluency	.12	.02	.00	.00	.23	.06
11. Originality	.27	.07	.08	.02	1.00	1.00
12. Category Flexibility	.00	.00	.16	.04	.52	.15
13. Induction	.44	.13	.40	.12	.40	.12
14. Syllogistic Reasoning	.59	.22	.37	.10	.06	.01
15. Arithmetic Reasoning	.75	.37	.82	.47	.62	.25
16. Number Facility	.62	.25	.88	.59	.09	.02
17. Problem Sensitivity	.82	.48	.81	.46	.87	.57
18. Flexibility of Closure	.68	.30	.53	.18	.82	.52
19. Perceptual Speed	.40	.12	.00	.00	.73	.35
20. Spatial Orientation	.78	.41	.67	.29	.85	.52
21. Spatial Scanning	.74	.36	.81	.46	.79	.43
22. Visualization	.66	.28	.85	.52	.69	.31
23. Auditory Perceptual Speed	.68	.29	.49	.16	.72	.34
24. Auditory Rhythm Discrimination	.46	.14	.00	.00	.70	.32
25. Arm-Hand Steadiness	.72	.34	.91	.66	.77	.41
26. Control Precision	.89	.61	.94	.75	.94	.78
27. Finger Dexterity	.67	.29	.51	.17	.69	.31
28. Manual Dexterity	.79	.42	.75	.38	.77	.41
29. Multilimb Coordination	.92	.68	.00	.00	.90	.65
30. Rate Control	.88	.58	.84	.52	.84	.52
31. Reaction Time	.48	.16	.40	.12	.81	.45
32. Speed of Arm Movement	.34	.09	.79	.43	.38	.11
33. Response Orientation	.64	.26	.02	.00	.81	.46
34. Wrist-Finger Speed	.29	.07	.38	.11	.00	.00
35. Verbal Expression	.79	.42	.93	.72	.52	.18
36. Attention	.57	.21	.06	.01	.72	.32
37. Time Sharing	.78	.41	.69	.31	.90	.63
38. Explosive Strength	.35	.10	.00	.00	.07	.01
39. Static Strength	.77	.40	.00	.00	.61	.24
40. Dynamic Strength	.54	.19	.00	.00	.49	.16
41. Extent Flexibility	.47	.15	.00	.00	.61	.24
42. Dynamic Flexibility	.35	.10	.00	.00	.74	.36
43. Gross Body Equilibrium	.58	.21	.00	.00	.81	.47
44. Gross Body Coordination	.47	.15	.00	.00	.72	.35
45. Stamina	.31	.08	.00	.00	.52	.18
46. Depth Perception	.75	.37	.00	.00	.97	.86
47. Color Discrimination	.67	.29	.00	.00	.91	.67
48. Near Visual Acuity	.08	.02	.00	.00	.00	.00
49. Far Visual Acuity	.88	.59	.40	.12	.93	.71
50. Kinesthetic Discrimination	.77	.40	.25	.06	.75	.37

Table 5 presents the percentage distributions for the ratings made by both the AIR judges and the outside judges on each ability for Task 1. Tables 6 through 10 present similar distributions for the remaining five tasks. Since the information contained in Table 5 is representative of the ability by ability "agreement" data shown in Tables 5 through 10, the following discussion will be confined to this table. An inspection of Table 5 reveals that "agreement" was reached on other than a zero rating in two instances by the AIR judges and in three instances by the APA judges. For the AIR judges "agreement" on other than a zero rating occurred on Abilities 26 and 30 (Control Precision and Rate Control). This occurred for the APA judges on Abilities 25, 26, and 30 (Arm-Hand Steadiness, Control Precision, and Rate Control). This imbalance in "agreement" between zero and non-zero (one and two) ratings occurred not only on Task 1 but on all of the tasks except Task 5 where "agreement" was low even on the rating of zero. The number of times "agreement" was achieved across all of the tasks is shown in Table 11.

In addition to determining the extent of "agreement" on specific abilities, the data were analyzed to determine the degree of similarity between pairs of ability profiles on each of the tasks. The statistic r_p was used for this purpose. For each sample of judges and on each task a value of r_p was calculated for every pair of profiles. For the AIR judges, there were 300 such possible pairs on each of the tasks and for the outside judges there were 120 possible pairs on each task. Table 12 gives the number of significant positive values of r_p which were found on each of the tasks. This table also indicates the proportion of the total number of relationships which are represented by the significant, positive values of r_p. For those unfamiliar with the r_p statistic, it ranges in value from -1.0 to +1.0 being asymptotic with respect to -1.0. An r_p value of +1.0 means

TABLE 5

Percentage Distributions of the
Ratings Given to Task 1
On Each of the Fifty Abilities

ABILITY	Percent of Judges in each Rating Category					
	AIR Judges			APA Judges		
	Zero	One	Two	Zero	One	Two
1. Verbal Comprehension	36	64	0	31	69	0
2. Associational Fluency	96	4	0	94	6	0
3. Word Fluency	100	0	0	94	6	0
4. Serial Recall	80	20	0	88	12	0
5. Free Recall	92	8	0	88	12	0
6. Paired Associate Memory	84	12	4	88	12	0
7. Memory for Operations	44	52	4	44	56	0
8. Memory for Ideas	76	20	4	56	44	0
9. Symbolic and Semantic Ordering	76	24	0	88	12	0
10. Ideational Fluency	100	0	0	88	12	0
11. Originality	96	4	0	94	6	0
12. Category Flexibility	100	0	0	88	12	0
13. Induction	88	12	0	88	12	0
14. Syllogistic Reasoning	100	0	0	81	19	0
15. Arithmetic Reasoning	92	8	0	88	12	0
16. Number Facility	92	8	0	88	12	0
17. Problem Sensitivity	60	36	4	88	12	0
18. Flexibility of Closure	52	32	16	38	62	0
19. Perceptual Speed	52	16	32	38	31	31
20. Spatial Orientation	56	16	28	25	50	25
21. Spatial Scanning	68	16	16	38	50	12
22. Visualization	64	8	28	50	32	18
23. Auditory Perceptual Speed	96	4	0	82	6	12
24. Auditory Rhythm Discrimination	100	0	0	82	12	6
25. Arm-Hand Steadiness	28	16	56	0	18	82
26. Control Precision	8	12	8	6	6	88
27. Finger Dexterity	40	48	12	31	38	31
28. Manual Dexterity	40	44	16	12	44	44
29. Multilimb Coordination	84	16	0	76	12	12
30. Rate Control	8	8	84	0	0	100
31. Reaction Time	36	20	44	6	18	76
32. Speed of Arm Movement	32	44	24	6	57	37
33. Response Orientation	52	28	20	18	57	25
34. Wrist-Finger Speed	56	28	16	25	44	31
35. Verbal Expression	96	4	0	94	6	0
36. Attention	16	44	40	6	44	50
37. Time Sharing	64	36	0	69	25	6
38. Explosive Strength	96	4	0	88	12	0
39. Static Strength	96	4	0	88	12	0
40. Dynamic Strength	96	0	4	69	25	6
41. Extent Flexibility	92	8	0	81	19	0
42. Dynamic Flexibility	92	0	8	63	31	6
43. Gross Body Equilibrium	92	8	0	63	31	6
44. Gross Body Coordination	96	4	0	63	31	6
45. Stamina	100	0	0	69	31	0
46. Depth Perception	52	32	16	38	50	12
47. Color Discrimination	44	36	20	75	19	6
48. Near Visual Acuity	24	44	32	19	62	19
49. Far Visual Acuity	72	24	4	56	44	0
50. Kinesthetic Discrimination	88	12	0	75	19	6

TABLE 6

Percentage Distributions of the
Rating Given to Task 2
On Each of the Fifty Abilities

ABILITY	Percent of Judges in each Rating Category					
	AIR Judges			APA Judges		
	Zero	One	Two	Zero	One	Two
1. Verbal Comprehension	24	72	4	13	56	31
2. Associational Fluency	84	16	0	63	25	12
3. Word Fluency	88	8	4	69	25	6
4. Serial Recall	44	40	16	19	50	31
5. Free Recall	48	44	8	37	44	19
6. Paired Associate Memory	32	32	36	31	50	19
7. Memory for Operations	8	28	64	0	37	63
8. Memory for Ideas	64	36	0	12	63	25
9. Symbolic and Semantic Ordering	28	36	36	44	31	25
10. Ideational Fluency	84	12	4	75	13	12
11. Originality	76	20	4	75	19	6
12. Category Flexibility	84	16	0	69	25	6
13. Induction	64	16	20	50	37	13
14. Syllogistic Reasoning	68	16	16	56	44	0
15. Arithmetic Reasoning	24	28	48	19	25	56
16. Number Facility	16	40	44	6	19	75
17. Problem Sensitivity	8	28	64	19	18	63
18. Flexibility of Closure	8	48	44	19	25	56
19. Perceptual Speed	48	20	32	25	31	44
20. Spatial Orientation	12	24	64	0	25	75
21. Spatial Scanning	8	28	64	0	25	75
22. Visualization	12	32	56	6	7	87
23. Auditory Perceptual Speed	40	28	32	44	19	37
24. Auditory Rhythm Discrimination	88	12	0	75	13	12
25. Arm-Hand Steadiness	80	16	4	75	19	6
26. Control Precision	84	8	8	75	19	6
27. Finger Dexterity	92	8	0	75	19	6
28. Manual Dexterity	92	8	0	81	13	6
29. Multilimb Coordination	100	0	0	81	13	6
30. Rate Control	88	8	4	50	19	31
31. Reaction Time	48	40	12	31	32	37
32. Speed of Arm Movement	84	16	0	81	13	6
33. Response Orientation	48	28	24	18	19	63
34. Wrist-Finger Speed	92	8	0	81	13	6
35. Verbal Expression	28	28	44	6	50	44
36. Attention	8	28	64	0	25	75
37. Time Sharing	20	16	64	18	19	63
38. Explosive Strength	100	0	0	87	13	0
39. Static Strength	100	0	0	81	19	0
40. Dynamic Strength	100	0	0	75	25	0
41. Extent Flexibility	100	0	0	81	19	0
42. Dynamic Flexibility	100	0	0	81	19	0
43. Gross Body Equilibrium	100	0	0	81	19	0
44. Gross Body Coordination	100	0	0	81	13	6
45. Stamina	100	0	0	69	26	0
46. Depth Perception	60	32	8	69	19	12
47. Color Discrimination	72	24	4	81	19	0
48. Near Visual Acuity	4	68	28	6	75	19
49. Far Visual Acuity	64	32	4	13	81	6
50. Kinesthetic Discrimination	88	8	4	87	7	6

TABLE 7
Percentage Distributions of the
Ratings Given to Task 3
On Each of the Fifty Abilities

ABILITY	Percent of Judges in each Rating Category					
	AIR JUDGES			APA JUDGES		
	Zero	One	Two	Zero	One	Two
1. Verbal Comprehension	60	40	0	69	31	0
2. Associational Fluency	100	0	0	100	0	0
3. Word Fluency	100	0	0	100	0	0
4. Serial Recall	68	20	12	63	37	0
5. Free Recall	88	8	4	100	0	0
6. Paired Associate Memory	96	4	0	100	0	0
7. Memory for Operations	28	36	36	19	44	37
8. Memory for Ideas	76	24	0	87	13	0
9. Symbolic and Semantic Ordering	84	12	4	75	25	0
10. Ideational Fluency	100	0	0	100	0	0
11. Originality	96	4	0	100	0	0
12. Category Flexibility	92	4	4	100	0	0
13. Induction	84	16	0	94	0	6
14. Syllogistic Reasoning	84	16	0	94	6	0
15. Arithmetic Reasoning	72	28	0	94	6	0
16. Number Facility	72	16	12	87	13	0
17. Problem Sensitivity	68	24	8	81	19	0
18. Flexibility of Closure	64	24	12	69	31	0
19. Perceptual Speed	56	24	20	63	12	25
20. Spatial Orientation	40	40	20	25	63	12
21. Spatial Scanning	52	40	8	50	31	19
22. Visualization	28	52	20	50	31	19
23. Auditory Perceptual Speed	100	0	0	100	0	0
24. Auditory Rhythm Discrimination	96	4	0	100	0	0
25. Arm-Hand Steadiness	12	44	44	13	37	50
26. Control Precision	16	24	60	6	44	50
27. Finger Dexterity	16	28	56	7	37	56
28. Manual Dexterity	4	44	52	0	69	31
29. Multilimb Coordination	36	48	16	44	44	12
30. Rate Control	68	32	0	56	37	7
31. Reaction Time	80	20	0	69	31	0
32. Speed of Arm Movement	64	24	12	44	56	0
33. Response Orientation	60	40	0	56	44	0
34. Wrist-Finger Speed	64	28	8	44	44	12
35. Verbal Expression	92	8	0	100	0	0
36. Attention	36	48	16	37	37	26
37. Time Sharing	84	12	4	75	25	0
38. Explosive Strength	76	16	8	87	7	6
39. Static Strength	48	24	28	50	44	6
40. Dynamic Strength	64	24	12	63	25	12
41. Extent Flexibility	96	4	0	69	31	0
42. Dynamic Flexibility	88	12	0	56	37	7
43. Gross Body Equilibrium	92	8	0	75	25	0
44. Gross Body Coordination	84	16	0	44	50	6
45. Stamina	92	8	0	56	44	0
46. Depth Perception	24	48	28	18	63	19
47. Color Discrimination	84	12	4	94	6	0
48. Near Visual Acuity	0	48	52	13	37	50
49. Far Visual Acuity	64	36	0	50	44	6
50. Kinesthetic Discrimination	34	16	0	81	13	6

TABLE 8
Percentage Distributions of the
Ratings Given to Task 4
On Each of the Fifty Abilities

ABILITY	Percent of Judges in each Rating Category					
	AIR JUDGES			APA JUDGES		
	Zero	One	Two	Zero	One	Two
1. Verbal Comprehension	28	56	16	19	50	31
2. Associational Fluency	88	8	4	81	19	0
3. Word Fluency	92	9	0	94	6	0
4. Serial Recall	60	36	4	56	37	7
5. Free Recall	68	32	0	69	25	6
6. Paired Associate Memory	84	12	4	69	31	0
7. Memory for Operations	4	28	68	13	37	50
8. Memory for Ideas	36	44	20	12	63	25
9. Symbolic and Semantic Ordering	48	32	20	31	44	25
10. Ideational Fluency	84	8	8	87	7	6
11. Originality	72	20	8	81	19	0
12. Category Flexibility	92	4	4	87	13	0
13. Induction	44	32	24	56	37	7
14. Syllogistic Reasoning	48	28	24	50	31	19
15. Arithmetic Reasoning	28	52	20	25	50	25
16. Number Facility	52	40	8	50	25	25
17. Problem Sensitivity	12	16	72	32	37	31
18. Flexibility of Closure	36	48	16	25	44	31
19. Perceptual Speed	36	40	24	37	19	44
20. Spatial Orientation	12	24	64	6	19	75
21. Spatial Scanning	20	24	56	0	44	56
22. Visualization	12	28	60	0	19	81
23. Auditory Perceptual Speed	84	16	0	81	13	6
24. Auditory Rhythm Discrimination	100	0	0	81	13	6
25. Arm-Hand Steadiness	20	36	44	6	44	50
26. Control Precision	12	16	72	0	13	87
27. Finger Dexterity	52	44	4	31	63	6
28. Manual Dexterity	48	40	12	31	56	13
29. Multilimb Coordination	60	36	4	56	31	13
30. Rate Control	16	4	80	0	25	75
31. Reaction Time	32	36	32	6	50	44
32. Speed of Arm Movement	44	52	4	44	56	6
33. Response Orientation	20	28	52	12	44	44
34. Wrist-Finger Speed	76	20	4	69	19	12
35. Verbal Expression	84	16	0	81	19	0
36. Attention	28	28	44	6	31	63
37. Time Sharing	48	20	32	63	12	25
38. Explosive Strength	92	8	0	81	13	6
39. Static Strength	100	0	0	87	7	6
40. Dynamic Strength	96	4	0	81	13	6
41. Extent Flexibility	100	0	0	81	13	6
42. Dynamic Flexibility	100	0	0	75	19	6
43. Gross Body Equilibrium	92	4	4	75	13	12
44. Gross Body Coordination	92	8	0	75	13	12
45. Stamina	96	4	0	81	6	13
46. Depth Perception	44	32	24	63	12	25
47. Color Discrimination	96	4	0	81	13	6
48. Near Visual Acuity	8	60	32	0	75	25
49. Far Visual Acuity	64	20	16	50	37	13
50. Kinesthetic Discrimination	68	20	12	50	37	13

TABLE 9

Percentage Distributions of the
Ratings Given to Task 5
On Each of the Fifty Abilities

ABILITY	Percent of Judges in Each Rating Category					
	AIR Judges			APA Judges		
	Zero	One	Two	Zero	One	Two
1. Verbal Comprehension	20	76	4	37	44	19
2. Associational Fluency	92	4	4	75	25	0
3. Word Fluency	96	4	0	81	19	0
4. Serial Recall	40	48	12	44	44	12
5. Free Recall	60	40	0	44	50	6
6. Paired Associate Memory	72	24	4	63	25	12
7. Memory for Operations	12	24	56	12	25	63
8. Memory for Ideas	44	36	20	37	44	19
9. Symbolic and Semantic Ordering	36	48	16	31	44	25
10. Ideational Fluency	84	16	0	81	19	0
11. Originality	72	28	0	100	0	0
12. Category Flexibility	92	8	0	69	31	0
13. Induction	56	40	4	63	25	12
14. Syllogistic Reasoning	72	28	0	87	7	6
15. Arithmetic Reasoning	56	40	4	63	19	18
16. Number Facility	56	40	4	63	37	0
17. Problem Sensitivity	20	40	40	19	37	44
18. Flexibility of Closure	8	20	72	6	19	75
19. Perceptual Speed	20	12	68	6	25	69
20. Spatial Orientation	4	4	92	6	19	75
21. Spatial Scanning	8	16	76	0	25	75
22. Visualization	36	36	28	6	44	50
23. Auditory Perceptual Speed	52	48	0	37	56	7
24. Auditory Rhythm Discrimination	72	24	4	50	50	0
25. Arm-Hand Steadiness	16	44	40	18	19	63
26. Control Precision	4	12	84	0	13	87
27. Finger Dexterity	44	48	8	50	31	19
28. Manual Dexterity	28	48	24	19	44	37
29. Multilimb Coordination	4	16	80	6	19	75
30. Rate Control	20	16	64	6	25	69
31. Reaction Time	24	36	40	6	44	50
32. Speed of Arm Movement	44	48	8	12	69	19
33. Response Orientation	8	32	60	6	31	63
34. Wrist-Finger Speed	44	56	0	50	44	6
35. Verbal Expression	76	24	0	69	31	0
36. Attention	16	20	64	12	25	63
37. Time Sharing	8	24	68	12	13	75
38. Explosive Strength	92	8	0	81	19	0
39. Static Strength	92	8	0	69	31	0
40. Dynamic Strength	64	36	0	50	31	19
41. Extent Flexibility	72	28	0	50	44	6
42. Dynamic Flexibility	64	36	0	31	50	19
43. Gross Body Equilibrium	56	32	12	31	37	32
44. Gross Body Coordination	64	28	8	37	37	26
45. Stamina	80	20	0	63	25	12
46. Depth Perception	8	16	76	0	6	94
47. Color Discrimination	32	40	28	19	50	31
48. Near Visual Acuity	12	48	40	13	50	37
49. Far Visual Acuity	0	8	92	0	19	81
50. Kinesthetic Discrimination	16	48	36	25	44	31

TABLE 10
Percentage Distributions of the
Ratings Given to Task 6
On Each of the Fifty Abilities

ABILITY	Percent of Judges in Each Rating Category					
	AIR Judges			APA Judges		
	Zero	One	Two	Zero	One	Two
1. Verbal Comprehension	20	64	16	25	63	12
2. Associational Fluency	88	8	4	81	13	6
3. Word Fluency	88	8	4	94	6	0
4. Serial Recall	40	36	24	19	56	25
5. Free Recall	48	36	16	56	31	13
6. Paired Associate Memory	36	24	40	37	19	44
7. Memory for Operations	32	48	20	31	56	13
8. Memory for Ideas	68	20	12	81	19	0
9. Symbolic and Semantic Ordering	72	24	4	69	19	12
10. Ideational Fluency	84	12	4	94	6	0
11. Originality	92	8	0	100	0	0
12. Category Flexibility	88	4	8	94	6	0
13. Induction	88	4	8	94	6	0
14. Syllogistic Reasoning	100	0	0	100	0	0
15. Arithmetic Reasoning	80	20	0	100	0	0
16. Number Facility	56	24	20	75	25	0
17. Problem Sensitivity	80	20	0	87	13	0
18. Flexibility of Closure	24	0	76	25	12	63
19. Perceptual Speed	16	28	56	12	13	75
20. Spatial Orientation	72	24	4	69	25	6
21. Spatial Scanning	60	24	16	56	25	19
22. Visualization	84	12	4	56	37	7
23. Auditory Perceptual Speed	80	12	8	87	7	6
24. Auditory Rhythm Discrimination	100	0	0	87	13	0
25. Arm-Hand Steadiness	68	32	0	63	37	0
26. Control Precision	88	12	0	81	19	0
27. Finger Dexterity	52	32	16	44	50	6
28. Manual Dexterity	84	16	0	63	37	0
29. Multilimb Coordination	100	0	0	87	13	0
30. Rate Control	84	8	8	63	31	6
31. Reaction Time	36	40	24	19	37	44
32. Speed of Arm Movement	64	20	16	31	56	13
33. Response Orientation	72	12	16	44	44	12
34. Wrist-Finger Speed	76	20	4	37	50	13
35. Verbal Expression	88	8	4	94	6	0
36. Attention	4	0	96	6	0	94
37. Time Sharing	64	28	8	81	13	6
38. Explosive Strength	100	0	0	100	0	0
39. Static Strength	100	0	0	100	0	0
40. Dynamic Strength	100	0	0	94	6	0
41. Extent Flexibility	100	0	0	100	0	0
42. Dynamic Flexibility	92	8	0	100	0	0
43. Gross Body Equilibrium	100	0	0	100	0	0
44. Gross Body Coordination	96	4	0	100	0	0
45. Stamina	100	0	0	100	0	0
46. Depth Perception	88	12	0	100	0	0
47. Color Discrimination	92	8	0	100	0	0
48. Near Visual Acuity	4	56	40	13	56	31
49. Far Visual Acuity	92	4	4	87	7	6
50. Kinesthetic Discrimination	92	8	0	94	0	6

TABLE 11

Number of Times "Agreement" Was Achieved on One of the Three Ratings by the Two Groups of Judges on Each of the Six Tasks

	AIR JUDGES			APA JUDGES		
Task	Zero	One	Two	Zero	One	Two
1	25	0	2	20	0	3
2	22	0	0	12	1	1
3	24	0	0	19	0	0
4	17	0	1	14	0	2
5	7	0	4	5	0	2
6	29	0	1	28	0	1

TABLE 12

Number of Significant Positive Relationships Among the Judges on the Six Tasks and the Proportion of the Total Number of Relationships which the Positives Constitute

	AIR JUDGES		OUTSIDE JUDGES	
Task	Number of Positive r_p's	Proportion of Total	Number of Positive r_p's	Proportion of Total
1	17	.06	16	.13
2	36	.12	16	.13
3	6	.02	4	.03
4	28	.09	8	.07
5	41	.14	7	.06
6	16	.05	9	.08

that two persons or profiles fall on exactly the same point in multi-dimensional space. An r_p value of 0.0 means that two persons fall as far apart as one would (on the average) expect for any two points taken at random. An r_p of -1.0 means that two persons are on opposite ends of the distribution. Examples of r_p values are given in Table 13. The ratings shown are ratings which were given by three pairs of AIR judges on Task 2. The first pair represents an r_p value of zero. The second pair represents a significant positive value of r_p ($r_{p\ .05} = .227$), and the third pair demonstrates a stronger, positive relationship between profiles.

Similarity coefficients were also calculated between the mean ability profiles obtained from the AIR and APA judges ratings of the tasks. The mean profiles were developed by calculating the mean rating given by each group of judges to each task on each ability scale. These profiles and the r_p values for each pair are shown in Tables 14 and 15. All of the obtained r_p values reveal significant agreement between the mean ratings of the AIR and APA judges.

Interview data with respect to the TAS and the task descriptions were obtained from both groups of judges. They will not be presented here, but will be incorporated when appropriate in the following section.

Discussion and Conclusions

The pilot study provided much valuable information regarding its primary objectives. In general, preliminary reliability data were obtained, the r_p statistic was shown to be an excellent tool for assessing interprofile similarity, and areas of change and improvement in the TAS were highlighted both by the data and the judges' comments.

TABLE 13
Examples of Three Levels of
the Similarity Coefficient r_p

Ability Number	Pair 1 r_p = -.0002		Pair 2 r_p = .2276		Pair 3 r_p = .7036	
	#1	#2	#1	#2	#1	#2
1	1	1	1	1	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	2	0	0	1	0	1
5	1	0	0	1	0	1
6	2	2	2	2	2	2
7	2	2	2	2	2	1
8	1	0	1	1	0	0
9	1	0	1	2	0	1
10	0	0	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
13	0	0	0	0	0	0
14	2	0	0	0	0	0
15	2	0	1	2	2	2
16	2	1	2	2	1	2
17	2	2	2	1	2	2
18	2	0	1	1	2	2
19	2	0	0	1	0	0
20	2	2	2	2	2	2
21	2	0	0	2	2	2
22	2	2	2	1	2	2
23	1	0	2	2	0	0
24	0	0	0	1	0	0
25	0	0	0	0	0	0
26	0	2	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	1	0	0
29	0	0	0	0	0	0
30	0	0	0	1	0	0
31	0	0	0	1	0	0
32	0	0	0	1	0	0
33	0	0	0	2	0	1
34	0	0	0	0	0	0
35	1	1	1	2	0	0
36	2	0	1	2	2	2
37	2	1	2	2	2	2
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0
42	0	0	0	0	0	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	1	2	0	0
47	1	0	0	1	0	0
48	1	1	1	1	1	1
49	0	0	1	1	1	1
50	0	0	0	1	0	0

TABLE 14

Similarity Between Mean Ability Profiles Given
by the AIR and APA Judges on
Task 1, 2, and 3

	TASK 1		TASK 2		TASK 3	
	r_p = .87		r_p = .86		r_p = .87	
	AIR	APA	AIR	APA	AIR	APA
1. Verbal Comprehension	.64	.69	.80	1.19	.40	.31
2. Associational Fluency	.04	.06	.16	.50	0.00	0.00
3. Word Fluency	0.00	.06	.16	.37	0.00	0.00
4. Serial Recall	.20	.13	.72	1.13	.44	.38
5. Free Recall	.08	.13	.60	.81	.16	0.00
6. Paired Associate Memory	.20	.13	1.04	.87	.04	0.00
7. Memory for Operations	.60	.56	1.56	1.62	1.08	1.19
8. Memory for Ideas	.28	.44	.36	1.12	.24	.13
9. Symbolic and Semantic Ordering	.24	.13	1.08	.81	.20	.25
10. Ideational Fluency	0.00	.13	.20	.37	0.00	0.00
11. Originality	.04	.06	.28	.31	.04	0.00
12. Category Flexibility	0.00	.13	.16	.37	.12	0.00
13. Induction	.12	.13	.56	.63	.16	.13
14. Syllogistic Reasoning	0.00	.19	.48	.44	.16	.06
15. Arithmetic Reasoning	.08	.13	1.24	1.37	.28	.06
16. Number Facility	.08	.13	1.28	1.69	.40	.13
17. Problem Sensitivity	.44	.13	1.56	1.44	.40	.19
18. Flexibility of Closure	.64	.63	1.36	1.37	.48	.31
19. Perceptual Speed	.80	.94	.84	1.19	.64	.63
20. Spatial Orientation	.72	1.00	1.52	1.75	.80	.87
21. Spatial Scanning	.48	.75	1.56	1.75	.56	.69
22. Visualization	.64	.69	1.44	1.81	.92	.69
23. Auditory Perceptual Speed	.04	.31	.92	.94	0.00	0.00
24. Auditory Rhythm Discrimination	0.00	.25	.12	.37	.04	0.00
25. Arm-Hand Steadiness	1.28	1.81	.24	.31	1.32	1.37
26. Control Precision	1.72	1.81	.24	.31	1.44	1.44
27. Finger Dexterity	.72	1.00	.08	.31	1.40	1.50
28. Manual Dexterity	.76	1.31	.08	.25	1.48	1.31
29. Multilimb Coordination	.16	.37	0.00	.25	.80	.69
30. Rate Control	1.76	2.00	.16	.81	.32	.50
31. Reaction Time	1.08	1.69	.64	1.06	.20	.31
32. Speed of Arm Movement	.92	1.31	.16	.25	.48	.56
33. Response Orientation	.68	1.06	.76	1.44	.40	.44
34. Wrist-Finger Speed	.60	.87	.08	.25	.44	.69
35. Verbal Expression	.04	.06	1.16	1.37	.08	0.00
36. Attention	1.24	1.44	1.56	1.75	.80	.87
37. Time Sharing	.36	.37	1.44	1.44	.20	.25
38. Explosive Strength	.04	.13	0.00	.12	.32	.19
39. Static Strength	.04	.13	0.00	.19	.80	.56
40. Dynamic Strength	.08	.37	0.00	.25	.48	.50
41. Extent Flexibility	.08	.19	0.00	.19	.04	.31
42. Dynamic Flexibility	.16	.44	0.00	.19	.12	.50
43. Gross Body Equilibrium	.08	.44	0.00	.19	.08	.25
44. Gross Body Coordination	.04	.44	0.00	.25	.16	.62
45. Stamina	0.00	.31	0.00	.31	.08	.44
46. Depth Perception	.64	.75	.48	.44	1.04	1.00
47. Color Discrimination	.76	.31	.32	.19	.20	.06
48. Near Visual Acuity	1.08	1.00	1.24	1.13	1.52	1.37
49. Far Visual Acuity	.32	.44	.40	.94	.36	.56
50. Kinesthetic Discrimination	.12	.31	.16	.19	.16	.25

TABLE 15
Similarity Between Mean Ability Profiles Given
by the AIR and APA Judges on
Task 4, 5, and 6

ABILITY	TASK 4 r_p = .87		TASK 5 r_p = .91		TASK 6 r_p = .88	
	AIR	APA	AIR	APA	AIR	APA
1. Verbal Comprehension	.88	1.13	.84	.81	.96	.81
2. Associational Fluency	.16	.19	.12	.25	.16	.25
3. Word Fluency	.08	.06	.04	.19	.16	.06
4. Serial Recall	.44	.50	.72	.69	.84	1.06
5. Free Recall	.32	.37	.40	.63	.68	.56
6. Paired Associate Memory	.20	.31	.32	.50	1.04	1.06
7. Memory for Operations	1.64	1.37	1.44	1.50	.88	.81
8. Memory for Ideas	.84	1.13	.76	.81	.44	.19
9. Symbolic and Semantic Ordering	.72	.94	.80	.94	.32	.44
10. Ideational Fluency	.24	.19	.16	.19	.20	.06
11. Originality	.36	.19	.28	0.00	.08	0.00
12. Category Flexibility	.12	.13	.08	.31	.20	.06
13. Induction	.80	.50	.48	.50	.20	.06
14. Syllogistic Reasoning	.76	.69	.28	.19	0.00	0.00
15. Arithmetic Reasoning	.92	1.00	.48	.56	.20	0.00
16. Number Facility	.56	.75	.48	.37	.64	.25
17. Problem Sensitivity	1.60	1.00	1.20	1.25	.20	.13
18. Flexibility of Closure	.80	1.06	1.64	1.69	1.52	1.37
19. Perceptual Speed	.88	1.06	1.48	1.63	1.40	1.63
20. Spatial Orientation	1.52	1.69	1.88	1.69	.32	.37
21. Spatial Scanning	1.36	1.56	1.68	1.75	.56	.63
22. Visualization	1.48	1.81	.92	1.44	.20	.50
23. Auditory Perceptual Speed	.16	.25	.48	.69	.28	.19
24. Auditory Rhythm Discrimination	0.00	.25	.32	.50	0.00	.13
25. Arm-Hand Steadiness	1.24	1.44	1.24	1.44	.32	.37
26. Control Precision	1.60	1.88	1.80	1.88	.12	.19
27. Finger Dexterity	.52	.75	.64	.69	.64	.63
28. Manual Dexterity	.64	.81	.96	1.19	.16	.37
29. Multilimb Coordination	.44	.56	1.76	1.69	0.00	.13
30. Rate Control	1.64	1.75	1.44	1.63	.24	.44
31. Reaction Time	1.00	1.37	1.16	1.44	.88	1.25
32. Speed of Arm Movement	.60	.62	.64	1.06	.52	.81
33. Response Orientation	1.32	1.31	1.52	1.56	.44	.69
34. Wrist-Finger Speed	.28	.44	.56	.56	.28	.75
35. Verbal Expression	.16	.19	.24	.31	.16	.06
36. Attention	1.16	1.56	1.48	1.50	1.92	1.87
37. Time Sharing	.84	.63	1.60	1.63	.44	.25
38. Explosive Strength	.08	.25	.08	.19	0.00	0.00
39. Static Strength	0.00	.19	.08	.31	0.00	0.00
40. Dynamic Strength	.04	.25	.36	.69	0.00	.06
41. Extent Flexibility	0.00	.25	.28	.56	0.00	0.00
42. Dynamic Flexibility	0.00	.31	.36	.87	.08	0.00
43. Gross Body Equilibrium	.12	.37	.56	1.00	0.00	0.00
44. Gross Body Coordination	.08	.37	.44	.87	.04	0.00
45. Stamina	.04	.31	.20	.50	0.00	0.00
46. Depth Perception	.80	.63	1.68	1.94	.12	0.00
47. Color Discrimination	.04	.25	.96	1.13	.08	0.00
48. Near Visual Acuity	1.24	1.25	1.28	1.25	1.36	1.19
49. Far Visual Acuity	.52	.63	1.92	1.81	.12	.19
50. Kinesthetic Discrimination	.44	.63	1.20	1.06	.08	.13

With respect to the reliability of the individual ability scales, the obtained intraclass correlation coefficients indicated that substantial reliability can be expected from the majority of the TAS scales if they are employed by a panel of judges. The coefficients obtained for the reliability of a single judge indicate that only one of the ability scales (Control Precision) could be used with any reliability by a single judge. The discrepancy among the r_1, r_5, and r_k values shown in Tables 3 and 4 indicates that the within task, within ability error variance is rather large and that it, therefore, would require a rather large panel of judges (e.g., n = 25, n = 16) to achieve a stable estimate of the rating of a task on an ability scale. This is reflected in the low values of r_p which were obtained between pairs of individual profiles. The low values indicate substantial difference in interjudge agreement as to the particular abilities and levels of abilities which account for performance on the tasks. This confirms the fact that a large pool of error variance exists in the judges' ratings. The higher values of r_p obtained for the comparison of mean profiles between groups of judges (Tables 14 and 15) support the statement made above with respect to the r_k values. That is, reliability on the TAS scales is possible, but for this reliability large groups of judges are required to achieve stable estimates of the ratings.

Although the data do not indicate the causes of the high error variance, the comments received from the judges suggest two possible sources of the error variance. First, probably the most pressing problem which was uncovered by the judges' comments involves the criteria for applying abilities to tasks. In the instructions given in the TAS, the judges are told to assign a task rating of "one" on a given ability when "the average person would exhibit the amount of the ability required", and to assign a rating of "two" when the ability

is required at an above base-line level; "that is, the average person would not exhibit the amount of the ability required." This criterion produces difficulty in that the "average" person can be considered as either experienced or naive on a given task. As has been shown in previous factor-analytic research (Fleishman & Hempel, 1955), the abilities required to perform a task change with respect to the amount of training a subject has on the task. Thus, the "average person" does not provide a stable reference criterion for assessing the involvement of an ability in a task. This lack of a stable criterion which can be equally employed by all of the judges would contribute heavily to differences among the judges' ratings of a task. To meet this problem, the concept of the "average person" will be discarded in future research.

A second possible reason of the error variance is the fact that some of the judges found it possible to account for the same portion of task performance by means of two different ability scales. The possibility of utilizing either of two abilities to account for the same aspect of performance, could cause some judges to choose one and some judges to choose the other. The result would be an increase in the error variance associated with both of the scales. Thus, there is a need to revise the TAS so as to carefully mark off the limits of each ability and to provide judges with the specific nature of the distinctions between abilities.

The investigation of the data by means of intraclass correlations was followed by an examination of the distributions which underlay the obtained correlation values. The distributions are presented as percentages in Tables 5 through 10. These distributions indicate that, in general, where reliability or "agreement" was obtained it was due to the fact that the judges rated the ability as a zero (Table 10).

In fact, on Ability 11 (Originality) the value, $r_{\overline{k}} = 1.0$, is due to the fact that on Tasks 3, 5, and 6 all of the $\overline{APA}$ judges rated the tasks as zero on this ability; hence, there was zero variance in the ratings. It was felt that the predominance of the zero ratings might be due to the fact that the sample of tasks employed in the pilot study did not cover a wide enough range of performance to require the use of all of the ability scales.

As a result of this study, two other points were brought forth which indicated the need for further revision of the TAS. First, there is evidently a need for further modification of the list of abilities on which the TAS is based. Some judges commented that there were elements in some of the tasks which could not be described in terms of the abilities in the list. Also, in light of other comments which were received, several of the ability definitions appear to warrant revision, with particular attention being given to the inclusion of more and better examples. Second, the use of only three rating categories is too restrictive both from an interpretive and a statistical point of view. A strong need for a more sophisticated scaling technique was indicated.

In summary, this pilot study provided valuable information concerning the further development of the TAS. As a result of this study, it was decided that further development of the TAS would center around the following areas:

(1) the use of a seven point rating scale to improve the quality of the data;

(2) development of a means for anchoring the ability rating scales;

(3) modification of the list of abilities upon which the TAS is founded;

(4) redefinition of several of the abilities so as to emphasize their scope and limits and to clearly distinguish them from similar abilities;

(5) the development of stable reference criteria for applying ability scales to tasks; and

(6) a change in the format for presenting the TAS.

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SECOND PILOT STUDY

Before the second pilot study could be initiated, two preparatory efforts had to be completed. First, the TAS had to be modified so as to reduce the overlap among abilities by carefully specifying the distinctions among the abilities and so as to reduce any ambiguities in the definitions of the abilities. Second, the scaling technique, employed in the previous pilot study, had to be revised in order to provide stable anchors for the scales, and to improve the metric quality of the rating data.

Modification of the TAS[2]

The 50 abilities from the version of the TAS used in the first pilot study were reorganized into a set of 37 abilities for the second pilot study (Table 16). This reorganization involved the elimination of some abilities, the condensation of some sets of abilities into smaller sets, or, in some cases, into single abilities, and the redefinition of most of the remaining abilities.

The redefinition of the abilities was intended to increase inter-judge reliability in the use of the TAS by reducing ambiguity in the definitions and by specifying the distinctions among abilities. This was accomplished by arranging the 50 abilities in groups according to the judged similarity among them. This process was aided by the comments concerning the definitions made by the judges in the first pilot study. Within each of the groups, the definitions were carefully examined to determine the scope of the behaviors encompassed by each group. The range of behaviors within each group was then partitioned into specifiably distinct categories of behavior and

[2] This form of the TAS can be found in Appendix C.

TABLE 16

Reorganization of the TAS for the
Second Pilot Study

TAS from Second Pilot Study	TAS from First Pilot Study
1. Verbal Comprehension	1. Verbal Comprehension
	2. Associational Fluency
2. Verbal Expression	3. Word Fluency
3. Ideational Fluency	10. Ideational Fluency
4. Originality	11. Originality
	35. Verbal Expression
	4. Serial Recall
	5. Free Recall
5. Memorization	6. Paired Associate Memory
	7. Memory for Operations
	8. Memory for Ideas
6. Problem Sensitivity	9. Symbolic and Semantic Ordering
7. Mathematical Reasoning	12. Category Flexibility
9. Deductive Reasoning	13. Induction
10. Inductive Reasoning	14. Syllogistic Reasoning
11. Information Ordering	15. Arithmetic Reasoning
12. Category Flexibility	17. Problem Sensitivity
8. Number Facility	16. Number Facility
13. Spatial Orientation	18. Flexibility of Closure
14. Visualization	20. Spatial Orientation
15. Speed of Closure	21. Spatial Scanning
16. Flexibility of Closure	22. Visualization
17. Selective Attention	36. Attention
18. Time Sharing	37. Time Sharing
19. Perceptual Speed	19. Perceptual Speed

TABLE 16 Cont'd.

TAS from Second Pilot Study	TAS from First Pilot Study
20. Static Strength	39. Static Strength
21. Explosive Strength	38. Explosive Strength
22. Dynamic Strength	40. Dynamic Strength
23. Stamina	45. Stamina
24. Extent Flexibility	41. Extent Flexibility
25. Dynamic Flexibility	42. Dynamic Flexibility
26. Gross Body Equilibrium	43. Gross Body Equilibrium
27. Choice Reaction Time	31. Reaction Time
28. Reaction Time	32. Speed of Arm Movement
29. Speed of Limb Movement	33. Response Orientation
30. Wrist-Finger Speed	34. Wrist-Finger Speed
31. Gross Body Coordination	27. Finger Dexterity
32. Multilimb Coordination	20. Manual Dexterity
33. Finger Dexterity	29. Multilimb Coordination
34. Manual Dexterity	44. Gross Body Coordination
35. Arm-Hand Steadiness	25. Arm-Hand Steadiness
36. Rate Control	26. Control Precision
37. Control Precision	30. Rate Control

definitions for each of these categories were then developed.

For the most part, this redefinition did not drastically alter the existing definitions, but rather, it removed terminology from similar or related definitions which might have served as a source of confusion among them. In the case of the abilities of Associational Fluency, Word Fluency, Ideational Fluency, Originality, and Verbal Expression, it was felt that the range of behaviors covered by these definitions could best be covered by a set of three definitions. Thus, this set of five abilities was reorganized into a set of three (See Table 16) which still covered the same range of behaviors.

The area of memory proved to be particularly difficult to redefine. Both the data from the first pilot study and the comments obtained from the judges indicated that the existing definitions were inadequate but neither of these sources could provide a basis for redefinition. This problem was compounded by the fact that a search of the literature could not produce a definitive factor-analytic study which could guide a meaningful division of this area into separate categories. Finally, all efforts by AIR staff members to produce definitions of subcategories of memory which could generally be agreed upon ended in failure. In light of this, it was decided to create a single memory ability which would emphasize the ability to memorize new information in a task setting and which would not consider the long-term recall of previously learned material.

Lastly, the sensory abilities were not included in the version of the TAS employed in the second pilot study. In attempting to adequately cover the sensory area, it quickly became apparent that a major effort would be needed to develop a comprehensive set of descriptors and their attendant definitions. Thus, a decision was made to eliminate these concepts from the TAS with the understanding that, if the results of the second

pilot study warranted further development of the TAS, the effort would be made to develop ability definitions in the sensory area. This decision was based upon the judgment that it was better, at that time, to obtain an immediate further estimate of the feasibility of utilizing ability scales in task classification than it was to become diverted into an effort to organize the sensory area.

In the above mentioned process of grouping and defining abilities, many distinctions among the ability definitions became apparent and were made explicit. In order to enhance the judges' comprehension of each ability definition and to reduce confusion among the definitions, it was decided to formally incorporate these distinctions into the TAS. Thus, in the version of the TAS employed in the second pilot study, these distinctions are listed below each of the ability definitions. It was hoped that they would enhance the reliability of the TAS.

Revision of the Scaling Techniques

In the first pilot study the judges rated the tasks on what was essentially a three point scale. In the second pilot study this was changed to a seven point scale and a new technique was employed to better anchor the scales. This anchoring technique was adopted from Smith and Kendall (1963). As it was employed in the present study, this technique utilized as scale anchors both definitions of the high and low ends of the scale and examples of tasks which, in an independent study, were rated as high, moderate, and low on each of the scales. The development of these anchors required a special study consisting of three separate steps.

Development of definition anchors. First, professional staff members of AIR, who were familiar with the abilities approach to task classification, were asked to develop definitions of the high and low ends of each of the 37 ability scales. This was an iterative process involving careful examination of the definition of each ability and development of definitions of high and low amounts of each ability. The process was terminated for a given ability scale when general agreement could be reached on the definitions of both the high and low ends of the scale. Examples of these definitions can be seen in the scales in Appendix C.

Generation of examples. Two panels, one consisting of AIR staff professionals and the other of students from an area university, were assembled to generate examples of tasks which would reflect high, moderate and low levels of each of the 37 abilities. The procedure for each individual was to take each ability definition in turn and generate examples of every day occupational or laboratory tasks thought to require the ability. Since the TAS was intended for use with judges who might be drawn from any of the behavioral or engineering sciences, both of the panels were instructed to generate examples which would be familiar to almost any judge who might possibly use the TAS. Approximately 1000 examples were developed in this manner.

Scaling of the examples. Once the examples had been generated, those examples which would be the most stable anchors had to be selected and, in order to place the examples at appropriate points along the ability scales, the scale values of the examples had to be established. To achieve these objectives, the following procedure was employed. Eighteen graduate students from an area

university were asked to rate each of the examples on the particular ability scale it was intended to reflect. These judges also were permitted the option of rejecting any example as not being representative of the scale on which it was to be rated. From these ratings, means and standard deviations for each example were obtained.

Three examples, one with a high scale value, one with a moderate scale value and one with a low scale value, were chosen to anchor each scale. To select the three examples for each scale, the mean ratings of all of the examples rated upon a particular scale were examined and grouped as being high, moderate, or low. Within each of these groups, that example with the smallest standard deviation was chosen to anchor the scale. This was the example about which there was most agreement among the judges on the amount of the ability required for that example. An effort was made to select examples with standard deviations of less than 1.0. However, in some instances this was not possible. The means and standard deviations of the examples, which were utilized in the TAS (see Appendix C), are shown in Table 17[3].

As can be seen in Table 17, for some scales it was possible to obtain a greater spread between the high, moderate, and low examples than for other scales. However, considerable discrimination between examples was achieved along with considerable agreement within examples. Considering their one standard deviation values and their positions on the ability scales, there was virtually no overlap among the three examples on each ability scale.

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[3] Although they are not presented in this report, the means and standard deviations for all of the examples, both those which were used and those which were rejected, are available.

TABLE 17

Means and Standard Deviations of the High, Average and Low Examples Used as Scale Anchors[4]

Ability Number		High	Average	Low	Ability Number		High	Average	Low
1.	M	5.9	2.7	1.4	20.	M	5.92	4.64	1.13
	SD	0.86	0.67	0.56		SD	0.84	0.98	0.33
2.	M	6.6	4.0	1.3	21.	M	6.81	6.61	1.03
	SD	0.56	0.72	0.48		SD	0.35	0.54	0.12
3.	M	4.9	3.5	1.3	22.	M	6.72	3.11	2.14
	SD	1.24	1.16	0.57		SD	0.49	1.09	1.12
4.	M	6.3	3.3	1.1	23.	M	6.90	6.72	1.26
	SD	0.60	0.92	0.32		SD	0.26	0.43	0.6
5.	M	5.7	4.4	2.0	24.	M	6.38	5.21	1.56
	SD	0.91	0.87	0.69		SD	0.83	1.17	0.81
6.	M	4.9	3.0	1.2	25.	M	6.46	5.41	1.55
	SD	0.98	1.17	0.51		SD	0.85	0.7	0.63
7.	M	6.7	4.3	1.42	26.	M	6.01	4.92	1.66
	SD	0.57	1.01	0.50		SD	0.92	1.01	0.80
8.	M	4.9	2.0	1.1	27.	M	6.81	4.88	3.79
	SD	1.04	0.84	0.24		SD	0.42	0.98	0.98
9.	M	5.7	2.4	1.2	28.	M	4.79	3.99	2.67
	SD	0.77	0.94	0.54		SD	1.68	1.51	1.25
10.	M	5.9	4.4	1.9	29.	M	4.84	3.14	1.74
	SD	0.93	0.89	0.86		SD	1.13	1.41	1.00
11.	M	6.1	3.2	1.2	30.	M	5.72	3.66	1.06
	SD	0.68	1.01	0.62		SD	1.09	1.15	0.24
12.	M	5.0	3.2	1.4	31.	M	6.16	5.21	3.84
	SD	1.28	1.17	0.58		SD	0.76	0.94	1.24
13.	M	6.0	3.3	2.6	32.	M	4.73	3.20	1.01
	SD	1.05	1.07	0.96		SD	1.06	0.99	0.05
14.	M	4.1	2.3	1.3	33.	M	6.09	3.48	1.22
	SD	1.44	0.94	0.45		SD	0.83	0.99	0.38
15.	M	4.9	3.8	1.9	34.	M	6.89	4.12	1.12
	SD	0.78	1.23	0.88		SD	0.32	1.01	0.35
16.	M	5.03	4.19	1.50	35.	M	6.75	3.28	1.29
	SD	1.21	0.97	0.69		SD	0.55	0.88	0.86
17.	M	5.37	4.29	2.31	36.	M	5.25	3.68	2.69
	SD	1.08	0.79	0.91		SD	1.00	1.09	1.06
18.	M	5.41	4.31	3.04	37.	M	6.42	3.39	1.00
	SD	1.13	0.81	0.89		SD	0.69	1.08	0.00
19.	M	4.77	3.43	2.43					
	SD	1.23	1.33	0.99					

[4]See Appendix C for the actual statement of the high, moderate and low examples used on each of the 37 ability scales.

Experimental Design

The next phase of the second pilot study was intended to determine the reliability of the revised version of the TAS and to determine whether the example anchors enhanced scale reliability.

Since it was hoped that the ability-based task classification system would be employed in later phases of the project by judges who might not be psychologists, the judges employed in this study were graduate students from an area university. Two groups of these judges were obtained. Group 1 (n = 19) was asked to rate a set of tasks on ability scales which were anchored both with definitions of high and low and with examples. Group 2 (n = 22) was given the identical rating task but their ability scales were anchored only with the definitions of high and low.[5] This experimental procedure was employed to determine the contribution of example anchors to scale reliability.

The rating instructions given to both groups of judges are shown in Appendix C. In general, the judges were instructed to follow a two stage rating procedure. First, they had to decide whether an ability was required for the performance of the task. If their decision was "no" (a rating of "zero"), they would proceed to the next ability scale. If their decision was "yes" they proceeded to the second step where they rated the task on a seven-point rating scale. In making these ratings, the judges were told to estimate the lowest amount of an ability which a subject could possess and still produce errorless performance on the task.

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[5] The version of the TAS, shown in Appendix C is that used by Group 1. The form used by Group 2 was different only in that the examples used as scale anchors were not present.

A set of six task descriptions were chosen for this pilot study. These tasks are listed in Table 18 and the complete task descriptions can be found in Appendix C. Four of these task descriptions (Air traffic controller, Sheet metal worker, Astronaut, Helicopter Pilot) were the same as those used in the first pilot study. The remaining two task descriptions (Automobile driving, Basketball game) were developed so as to be familiar to the judges who were rating the tasks. This was done to determine whether the judges would be more reliable in rating tasks with which they were familiar.

TABLE 18

List of Task Descriptions Used in Second Pilot Study

Number	Task
1.	Automobile driving
2.	Air traffic controller
3.	Sheet metal worker
4.	Astronaut
5.	Helicopter pilot
6.	Basketball game

To determine whether these task descriptions were truely more familiar to the judges, the judges were asked to rate each of the six task descriptions on a set of six rating scales (see Appendix C). These seven-point scales measured the following aspects of the judges' familiarity with the task descriptions: 1) degree of understanding, 2) completeness of task description, 3) clarity of task description, 4) degree of familiarity, 5) degree of experience, and 6) degree of proficiency.

Analysis and Results

The analysis of the data from the second pilot study essentially paralleled that from the first pilot study. To determine interjudge reliability, intraclass correlation coefficients were calculated and the percentage distributions of the judges' ratings were examined; similarity coefficients were used to determine similarity between pairs of task ability profiles.

The intraclass correlation data are shown in Table 19. These data indicate that substantial reliability was achieved ($r_{\overline{k}}$) using a large panel of judges (19 or 22), but that little reliability can be expected if the TAS is to be employed by a single judge ($r_{\overline{1}}$). However, for small groups of judges ($r_{\overline{5}}$) about half of the scales (53% for Group 1 and 50% for Group 2) show reliability estimates greater than 0.70. While these would not be acceptable in a final version of the TAS, they should be considered acceptable for a pilot study.

The intraclass correlations were also examined with respect to the use of examples as scale anchors. This investigation revealed that Group 1 was no different from Group 2 and, therefore, that no enhancement of scale reliability could be attributed to the use of the examples. Thus, the improvement which was noted from the final study to the second must be attributed to the improved ability definitions, better defined scales and more detailed rating instructions.

Just as in the first pilot study, the percentage distributions of the judges' ratings were examined to gain some insight into the nature of the intraclass correlations. These distributions are shown in Tables 20 to 25. In addition, the means and standard deviations of the frequency distributions from which these percentage distributions were calculated are shown in Tables 26 to 31.

TABLE 19

Average (r_k), Group (r_5), and Individual (r_1) Reliabilities for Both Groups of Judges

Ability	GROUP 1			GROUP 2		
	r_k	r_5	r_1	r_k	r_5	r_1
1. Verbal Comprehension	.95	.83	.49	.94	.77	.40
2. Verbal Expression	.91	.73	.35	.95	.80	.45
3. Ideational Fluency	.60	.29	.08	.71	.35	.10
4. Originality	.68	.36	.10	.81	.50	.17
5. Memorization	.81	.53	.19	.90	.67	.28
6. Problem Sensitivity	.85	.60	.23	.90	.67	.29
7. Mathematical Reasoning	.98	.94	.75	.97	.89	.61
8. Number Facility	.97	.90	.65	.97	.89	.63
9. Deductive Reasoning	.68	.36	.10	.85	.56	.20
10. Inductive Reasoning	.72	.40	.12	.87	.50	.17
11. Information Ordering	.94	.81	.45	.92	.71	.33
12. Category Flexibility	.72	.40	.12	.73	.38	.11
13. Spatial Orientation	.96	.85	.53	.92	.72	.34
14. Visualization	.94	.80	.45	.88	.61	.24
15. Speed of Closure	.74	.43	.13	.65	.30	.08
16. Flexibility of Closure	.83	.57	.21	.82	.52	.18
17. Selective Attention	.53	.23	.06	.72	.37	.11
18. Time Sharing	.93	.78	.42	.93	.74	.36
19. Perceptual Speed	.87	.65	.27	.89	.66	.28
20. Static Strength	.63	.31	.08	.80	.48	.16
21. Explosive Strength	.96	.86	.56	.97	.90	.63
22. Dynamic Strength	.97	.90	.64	.97	.89	.62
23. Stamina	.96	.87	.57	.97	.89	.62
24. Extent Flexibility	.96	.85	.53	.97	.88	.60
25. Dynamic Flexibility	.93	.78	.42	.97	.87	.57
26. Gross Body Equilibrium	.93	.77	.40	.95	.80	.45
27. Choice Reaction Time	.92	.75	.37	.94	.77	.40
28. Reaction Time	.92	.75	.38	.93	.75	.37
29. Speed of Limb Movement	.93	.77	.41	.96	.83	.50
30. Wrist Finger Speed	.89	.68	.30	.89	.65	.27
31. Gross Body Equilibrium	.95	.84	.52	.96	.84	.52
32. Multilimb Coordination	.84	.59	.22	.93	.75	.38
33. Finger Dexterity	.77	.47	.15	.84	.54	.19
34. Manual Dexterity	.83	.57	.21	.87	.59	.23
35. Arm-Hand Steadiness	.79	.50	.16	.89	.64	.26
36. Rate Control	.87	.64	.26	.81	.49	.16
37. Control Precision	.93	.79	.43	.79	.44	.14

TABLE 20

Percentage Distributions of the Ratings Given to
Task 1 on Each of the Thirty-Seven Abilities

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
1. Verbal Comprehension	1	63	21	5	11	0	0	0	0
	2	41	32	9	5	8	5	0	0
2. Verbal Expression	1	95	0	0	0	0	0	5	0
	2	77	13	0	0	0	5	5	0
3. Ideational Fluency	1	53	16	5	11	5	5	5	0
	2	50	5	9	10	13	13	0	0
4. Originality	1	37	21	11	21	0	5	0	5
	2	31	9	18	18	13	5	0	5
5. Memorization	1	53	0	21	0	16	10	0	0
	2	22	18	18	9	23	10	0	0
6. Problem Sensitivity	1	5	16	11	16	26	11	5	11
	2	0	9	9	22	27	9	18	5
7. Mathematical Reasoning	1	79	5	16	0	0	0	0	0
	2	77	5	9	5	4	0	0	0
8. Number Facility	1	79	11	5	0	0	5	0	0
	2	72	13	9	0	0	6	0	0
9. Deductive Reasoning	1	10	11	31	16	11	16	0	5
	2	9	31	13	9	18	9	5	6
10. Inductive Reasoning	1	53	21	5	0	5	0	11	5
	2	36	31	0	9	9	5	5	5
11. Information Ordering	1	21	26	15	27	0	0	5	5
	2	6	18	13	13	31	5	5	9
12. Category Flexibility	1	84	0	0	11	5	0	0	0
	2	36	9	22	13	9	5	6	0
13. Spatial Orientation	1	11	21	21	26	21	0	0	0
	2	0	5	9	13	22	13	27	10
14. Visualization	1	31	11	21	26	0	5	0	6
	2	22	9	6	10	18	9	13	13
15. Speed of Closure	1	42	0	26	21	5	0	0	6
	2	18	9	5	13	13	18	18	6
16. Flexibility of Closure	1	36	5	15	15	11	0	11	6
	2	13	5	9	9	27	18	9	10
17. Selective Attention	1	0	11	21	11	11	21	4	21
	2	5	0	5	5	18	36	27	4
18. Time Sharing	1	11	21	15	21	15	11	0	6
	2	18	9	9	13	5	36	5	5
19. Perceptual Speed	1	15	11	31	11	11	11	0	10
	2	0	0	14	6	27	22	13	18
20. Static Strength	1	21	47	15	5	6	0	0	6
	2	22	32	13	9	9	9	0	6
21. Explosive Strength	1	31	26	11	21	5	6	0	0
	2	40	27	5	9	9	5	0	5
22. Dynamic Strength	1	68	11	15	6	0	0	0	0
	2	59	31	0	5	0	0	5	0
23. Stamina	1	42	42	5	5	6	0	0	0
	2	50	27	13	5	0	0	5	0
24. Extent Flexibility	1	5	42	26	21	0	0	0	6
	2	9	54	18	5	14	0	0	0

TABLE 20 Cont'd.

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
25. Dynamic Flexibility	1	21	11	21	15	11	15	0	6
	2	13	27	9	9	27	0	10	6
26. Gross Body Equilibrium	1	52	21	11	0	5	6	5	0
	2	45	22	5	13	9	6	0	0
27. Choice Reaction Time	1	0	0	11	5	42	21	0	21
	2	6	0	9	13	22	9	22	19
28. Reaction Time	1	0	0	6	26	36	6	5	21
	2	0	0	0	22	9	23	23	23
29. Speed of Limb Movement	1	0	0	15	47	6	6	15	11
	2	9	5	0	13	22	9	27	14
30. Wrist Finger Speed	1	6	15	31	21	15	6	0	6
	2	0	9	9	5	22	27	22	6
31. Gross Body Equilibrium	1	47	21	15	6	11	0	0	0
	2	27	9	6	18	22	9	9	0
32. Multilimb Coordination	1	0	15	6	15	36	11	6	11
	2	0	9	18	0	27	18	5	23
33. Finger Dexterity	1	26	31	31	11	0	0	0	0
	2	13	18	22	27	5	5	0	10
34. Manual Dexterity	1	5	26	21	15	21	6	6	0
	2	9	9	9	18	22	13	14	6
35. Arm-Hand Steadiness	1	15	21	15	21	11	0	11	6
	2	22	18	9	5	22	6	18	0
36. Rate Control	1	15	11	5	11	26	11	21	0
	2	13	5	5	13	18	13	14	19
37. Control Precision	1	0	11	11	31	26	11	0	10
	2	5	5	18	5	36	9	9	13

TABLE 21

Percentage Distributions of the Rating Given to Task 2 on Each of Thirty-Seven Abilities

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
1. Verbal Comprehension	1	5	5	12	0	26	15	15	22
	2	0	4	13	5	18	5	13	40
2. Verbal Expression	1	5	5	15	15	22	6	16	16
	2	0	5	5	0	18	5	27	40
3. Ideational Fluency	1	36	16	6	6	5	21	5	5
	2	28	9	0	9	22	13	13	5
4. Originality	1	42	11	0	15	0	11	21	0
	2	18	9	5	5	22	5	22	13
5. Memorization	1	52	0	21	0	15	12	0	0
	2	0	13	6	9	22	5	40	5
6. Problem Sensitivity	1	5	15	11	15	26	11	5	12
	2	0	13	6	9	9	13	32	18
7. Mathematical Reasoning	1	0	0	0	5	21	47	11	16
	2	0	9	13	0	13	23	32	10
8. Number Facility	1	5	0	0	0	32	15	43	5
	2	0	9	0	13	6	13	36	23
9. Deductive Reasoning	1	6	0	0	22	48	7	17	0
	2	9	18	6	9	13	18	18	9
10. Inductive Reasoning	1	22	5	22	5	15	5	15	11
	2	18	9	22	13	9	14	6	9
11. Information Ordering	1	0	0	0	15	52	11	11	11
	2	5	0	5	9	18	9	31	23
12. Category Flexibility	1	36	5	12	5	11	11	15	5
	2	32	5	5	9	13	18	9	9
13. Spatial Orientation	1	11	0	0	5	21	47	11	5
	2	10	6	13	9	9	0	13	40
14. Visualization	1	5	0	5	11	26	15	22	16
	2	9	5	5	5	9	9		
15. Speed of Closure	1	57	0	0	0	0	27	16	0
	2	13	8	4	13	18	5	18	21
16. Flexibility of Closure	1	36	0	5	11	5	21	11	11
	2	9	5	5	18	22	5	18	18
17. Selective Attention	1	36	15	11	0	11	12	15	0
	2	6	0	9	18	13	9	18	27
18. Time Sharing	1	6	0	0	16	0	36	36	6
	2	14	0	0	18	9	18	13	28
19. Perceptual Speed	1	11	5	0	0	11	31	21	21
	2	0	5	9	0	23	9	31	23
20. Static Strength	1	89	0	0	5	0	0	0	6
	2	82	13	5	0	0	0	0	0
21. Explosive Strength	1	84	11	0	0	0	5	0	0
	2	86	9	5	0	0	0	0	0
22. Dynamic Strength	1	78	12	5	5	0	0	0	0
	2	95	0	5	0	0	0	0	0
23. Stamina	1	78	16	0	0	0	0	6	0
	2	68	5	5	5	12	5	0	0
24. Extent Flexibility	1	63	15	5	12	5	0	0	0
	2	77	9	9	0	0	5	0	0

TABLE 21 Con't.

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
25. Dynamic Flexibility	1	73	5	5	0	12	5	0	0
	2	77	5	13	0	5	0	0	0
26. Gross Body Equilibrium	1	85	5	0	5	0	0	5	0
	2	86	0	0	0	5	0	9	0
27. Choice Reaction Time	1	11	0	5	5	15	31	21	11
	2	13	6	0	13	23	9	27	9
28. Reaction Time	1	12	5	5	11	15	21	26	5
	2	13	0	9	14	14	9	23	18
29. Speed of Limb Movement	1	57	11	5	11	5	11	0	0
	2	63	9	0	5	9	5	9	0
30. Wrist Finger Speed	1	57	11	11	0	11	5	5	0
	2	45	9	5	9	18	5	4	4
31. Gross Body Equilibrium	1	84	11	0	0	0	5	0	0
	2	76	5	5	0	0	0	9	5
32. Multilimb Coordination	1	78	5	5	0	12	0	0	0
	2	50	13	0	9	0	14	0	14
33. Finger Dexterity	1	57	11	22	0	5	0	5	0
	2	26	18	18	13	9	5	9	0
34. Manual Dexterity	1	47	11	22	15	0	5	0	0
	2	40	13	18	5	5	0	5	14
35. Arm-Hand Steadiness	1	63	15	11	0	0	5	5	0
	2	50	13	12	5	5	4	0	9
36. Rate Control	1	68	5	0	0	5	12	5	5
	2	40	0	0	5	9	5	27	14
37. Control Precision	1	30	5	5	0	5	27	16	6
	2	13	5	13	0	4	22	13	30

TABLE 22

Percentage Distributions of the Rating Given to

Task 3 on Each of Thirty-Seven Abilities

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
1. Verbal Comprehension	1	73	22	5	0	0	0	0	0
	2	64	9	9	9	9	0	0	0
2. Verbal Expression	1	73	22	0	5	0	0	0	0
	2	77	9	5	0	9	0	0	0
3. Ideational Fluency	1	68	11	21	0	0	0	0	0
	2	59	18	9	9	5	0	0	0
4. Originality	1	73	22	5	0	0	0	0	0
	2	41	41	18	0	0	0	0	0
5. Memorization	1	36	22	15	0	15	12	0	0
	2	27	18	22	9	13	5	0	6
6. Problem Sensitivity	1	5	31	42	16	6	0	0	0
	2	13	31	31	9	5	0	5	6
7. Mathematical Reasoning	1	68	5	22	0	0	5	0	0
	2	45	22	10	18	5	0	0	0
8. Number Facility	1	68	15	5	6	0	0	0	6
	2	51	27	9	13	0	0	0	0
9. Deductive Reasoning	1	15	31	36	6	6	6	0	0
	2	13	41	28	13	0	0	0	5
10. Inductive Reasoning	1	47	36	12	0	0	5	0	0
	2	32	36	27	0	5	0	0	0
11. Information Ordering	1	21	11	42	15	5	0	5	0
	2	0	32	23	9	22	9	5	0
12. Category Flexibility	1	57	22	15	0	0	6	0	0
	2	45	27	13	9	6	0	0	0
13. Spatial Orientation	1	47	21	32	0	0	0	0	0
	2	27	27	18	5	13	5	5	0
14. Visualization	1	26	42	11	5	11	5	0	0
	2	18	18	27	0	18	5	9	5
15. Speed of Closure	1	68	15	12	0	5	0	0	0
	2	36	13	13	22	6	0	9	0
16. Flexibility of Closure	1	26	52	11	11	0	0	0	0
	2	36	36	5	18	0	5	0	0
17. Selective Attention	1	26	15	31	11	12	0	0	5
	2	9	18	18	9	27	5	9	5
18. Time Sharing	1	68	22	5	0	0	5	0	0
	2	68	9	13	5	0	0	5	0
19. Perceptual Speed	1	5	57	15	12	11	0	0	0
	2	13	32	22	13	9	5	6	0
20. Static Strength	1	12	31	21	0	26	5	5	0
	2	27	13	18	5	32	5	0	0
21. Explosive Strength	1	15	21	11	31	15	0	5	0
	2	45	18	9	9	5	9	5	0
22. Dynamic Strength	1	36	21	15	11	12	0	5	0
	2	68	5	13	9	5	0	0	0
23. Stamina	1	36	32	12	5	0	5	5	5
	2	40	27	5	9	9	5	5	0
24. Extent Flexibility	1	0	52	11	11	21	0	5	0
	2	27	40	9	18	5	0	0	0

TABLE 22 Con'd.

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
25. Dynamic Flexibility	1	21	21	26	15	5	5	5	0
	2	13	50	0	9	18	5	5	0
26. Gross Body Equilibrium	1	57	26	12	0	5	0	0	0
	2	63	22	9	6	0	0	0	0
27. Choice Reaction Time	1	32	36	0	5	27	0	0	0
	2	45	18	22	5	5	5	0	0
28. Reaction Time	1	26	42	11	5	15	0	0	0
	2	22	32	27	0	19	0	0	0
29. Speed of Limb Movement	1	22	31	21	21	0	5	0	0
	2	22	18	18	9	22	0	5	6
30. Wrist Finger Speed	1	11	15	42	11	11	10	0	0
	2	0	23	18	23	14	13	9	0
31. Gross Body Equilibrium	1	32	31	26	0	11	0	0	0
	2	45	13	18	13	9	0	0	0
32. Multilimb Coordination	1	5	22	31	5	32	5	0	0
	2	18	22	13	9	18	9	5	6
33. Finger Dexterity	1	5	5	26	26	26	5	5	0
	2	5	9	18	18	18	6	10	18
34. Manual Dexterity	1	12	15	26	15	15	12	5	0
	2	5	13	13	18	5	9	14	23
35. Arm-Hand Steadiness	1	11	11	11	21	26	15	0	5
	2	5	23	9	6	13	13	13	18
36. Rate Control	1	73	5	0	0	5	12	5	0
	2	40	0	0	5	9	5	21	14
37. Control Precision	1	15	12	21	21	21	5	0	5
	2	9	18	6	10	9	22	13	13

TABLE 23

Percentage Distribution of the Rating Given to Task 4 on Each of Thirty-Seven Abilities

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
1. Verbal Comprehension	1	42	0	0	0	11	15	16	16
	2	36	5	5	0	13	9	9	23
2. Verbal Expression	1	52	0	0	0	5	15	12	16
	2	41	0	9	0	18	0	9	23
3. Ideational Fluency	1	47	0	0	11	15	5	6	16
	2	36	9	0	0	22	10	10	13
4. Originality	1	47	0	5	0	15	15	12	6
	2	18	9	5	5	22	6	23	14
5. Memorization	1	22	0	6	6	12	22	26	11
	2	5	6	9	9	9	18	31	13
6. Problem Sensitivity	1	11	0	11	5	11	5	42	15
	2	0	9	5	5	18	5	22	36
7. Mathematical Reasoning	1	0	0	0	5	5	15	47	26
	2	0	5	0	5	5	22	13	50
8. Number Facility	1	5	0	5	0	5	21	26	36
	2	9	0	5	5	5	13	13	50
9. Deductive Reasoning	1	22	5	5	0	26	15	15	12
	2	9	5	5	5	9	22	27	18
10. Inductive Reasoning	1	32	5	5	0	21	21	5	11
	2	13	13	9	5	22	10	14	14
11. Information Ordering	1	5	0	0	6	6	36	15	32
	2	0	0	0	5	13	5	36	41
12. Category Flexibility	1	57	0	0	11	11	0	0	21
	2	18	18	9	5	13	13	14	10
13. Spatial Orientation	1	11	0	0	0	0	0	32	42
	2	5	5	0	5	5	5	30	45
14. Visualization	1	6	0	0	6	0	16	36	36
	2	0	0	0	0	5	22	27	46
15. Speed of Closure	1	31	5	0	0	15	11	15	21
	2	32	0	9	5	5	0	18	31
16. Flexibility of Closure	1	36	0	0	5	11	12	21	15
	2	13	6	5	9	9	18	27	13
17. Selective Attention	1	47	5	0	5	11	12	5	15
	2	27	9	9	5	5	9	22	14
18. Time Sharing	1	12	0	5	5	15	5	11	47
	2	5	0	0	6	13	18	40	18
19. Perceptual Speed	1	10	0	11	0	5	11	42	21
	2	13	0	0	0	9	10	40	28
20. Static Strength	1	36	26	26	6	0	0	6	0
	2	63	28	0	0	0	0	0	9
21. Explosive Strength	1	57	37	6	0	0	0	0	0
	2	62	18	5	5	5	0	0	0
22. Dynamic Strength	1	68	22	0	5	5	0	0	0
	2	72	28	0	0	0	0	0	0
23. Stamina	1	63	15	0	6	6	0	5	5
	2	45	18	18	9	5	0	0	5
24. Extent Flexibility	1	26	42	27	0	5	0	0	0
	2	50	9	13	5	13	5	5	0

TABLE 23 Con'd.

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
25. Dynamic Flexibility	1	36	21	5	5	15	6	6	6
	2	40	23	23	9	0	0	0	5
26. Gross Body Equilibrium	1	52	5	5	5	11	5	5	11
	2	50	9	5	0	5	13	0	18
27. Choice Reaction Time	1	11	0	0	5	5	11	21	47
	2	9	5	5	5	5	27	18	26
28. Reaction Time	1	5	0	11	0	15	5	27	37
	2	13	0	0	0	23	18	18	28
29. Speed of Limb Movement	1	21	11	11	5	21	15	16	0
	2	36	9	14	13	28	0	0	0
30. Wrist Finger Speed	1	21	15	11	0	15	16	16	6
	2	18	5	13	13	36	5	5	5
31. Gross Body Equilibrium	1	57	11	5	0	6	0	6	15
	2	36	18	9	9	13	4	9	0
32. Multilimb Coordination	1	53	5	0	5	5	5	15	12
	2	50	9	0	22	9	0	5	5
33. Finger Dexterity	1	52	12	0	0	15	5	0	16
	2	31	5	5	23	23	0	13	0
34. Manual Dexterity	1	30	11	15	0	11	11	11	11
	2	22	9	5	9	27	5	5	18
35. Arm-Hand Steadiness	1	36	5	5	0	11	5	26	10
	2	23	0	5	13	22	18	13	6
36. Rate Control	1	21	5	0	5	0	11	22	36
	2	27	0	0	5	9	5	27	27
37. Control Precision	1	0	0	0	0	0	11	26	63
	2	13	0	0	0	5	6	13	63

TABLE 24

Percentage Distributions of the Rating Given

To Task 5 on Each of Thirty-Seven Abilities

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
1. Verbal Comprehension	1	5	6	16	15	26	22	5	5
	2	9	13	0	28	13	9	28	0
2. Verbal Expression	1	26	5	15	11	26	5	0	12
	2	31	18	13	5	9	18	5	0
3. Ideational Fluency	1	47	15	0	5	11	11	0	11
	2	28	5	18	13	18	9	9	0
4. Originality	1	32	11	15	11	15	11	0	5
	2	32	5	5	9	9	13	27	0
5. Memorization	1	15	15	5	5	15	21	12	11
	2	5	0	9	5	27	9	27	18
6. Problem Sensitivity	1	0	5	15	22	5	15	16	22
	2	0	6	5	9	9	13	31	27
7. Mathematical Reasoning	1	36	5	12	5	15	5	16	6
	2	32	9	13	0	13	18	9	6
8. Number Facility	1	42	5	5	15	12	11	5	5
	2	45	5	9	5	9	27	0	0
9. Deductive Reasoning	1	15	5	11	22	22	15	5	5
	2	5	9	9	5	27	9	23	9
10. Inductive Reasoning	1	36	0	0	21	15	11	12	5
	2	13	9	9	13	18	13	19	6
11. Information Ordering	1	12	0	21	15	21	15	11	5
	2	5	0	5	18	22	5	36	9
12. Category Flexibility	1	42	5	5	11	11	15	0	11
	2	32	0	13	9	13	13	14	6
13. Spatial Orientation	1	11	0	0	0	0	15	31	42
	2	5	0	0	0	5	9	27	54
14. Visualization	1	32	0	21	21	5	11	5	5
	2	10	0	5	5	9	18	13	40
15. Speed of Closure	1	36	10	0	11	21	11	11	0
	2	13	6	5	9	9	18	27	13
16. Flexibility of Closure	1	11	0	0	5	22	15	31	16
	2	13	6	0	13	13	9	18	28
17. Selective Attention	1	26	5	0	15	22	5	15	12
	2	0	0	5	9	23	23	22	18
18. Time Sharing	1	11	0	5	11	26	11	31	5
	2	6	0	13	13	18	23	13	14
19. Perceptual Speed	1	5	0	11	26	11	15	26	5
	2	5	5	0	9	22	5	36	18
20. Static Strength	1	26	26	31	5	0	0	0	12
	2	22	10	31	13	5	5	9	5
21. Explosive Strength	1	52	15	15	12	0	0	0	6
	2	59	9	14	0	9	0	9	0
22. Dynamic Strength	1	36	32	22	0	5	0	0	5
	2	28	28	13	13	13	5	0	0
23. Stamina	1	21	42	21	5	11	0	0	0
	2	36	14	9	9	27	0	0	5
24. Extent Flexibility	1	12	31	42	15	0	0	0	0
	2	27	27	13	13	14	6	0	0

TABLE 24 Con'd.

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
25. Dynamic Flexibility	1	15	26	11	26	11	11	0	0
	2	23	5	27	0	13	5	18	9
26. Gross Body Equilibrium	1	53	27	5	5	0	5	5	0
	2	31	9	5	13	18	9	9	6
27. Choice Reaction Time	1	0	0	0	26	16	16	26	16
	2	10	0	6	14	13	22	13	22
28. Reaction Time	1	5	5	11	21	21	15	11	11
	2	0	0	6	13	18	22	5	36
29. Speed of Limb Movement	1	10	21	11	5	26	11	11	5
	2	0	10	5	9	27	18	22	9
30. Wrist Finger Speed	1	22	12	15	11	15	5	5	15
	2	0	13	5	18	18	22	18	6
31. Gross Body Equilibrium	1	43	26	15	5	11	0	0	0
	2	10	13	10	10	22	13	13	9
32. [illegible]limb Coordination	1	12	26	0	5	26	21	5	5
	2	0	6	0	9	23	22	27	13
33. Finger Dexterity	1	47	21	0	11	0	21	0	0
	2	14	5	18	27	18	0	13	5
34. Manual Dexterity	1	26	11	5	15	12	15	11	5
	2	6	0	9	18	22	5	22	18
35. Arm-Hand Steadiness	1	26	0	11	15	11	11	11	15
	2	9	0	14	9	23	5	18	22
36. Rate Control	1	15	15	0	0	5	31	22	12
	2	14	0	6	5	13	9	22	31
37. Control Precision	1	5	0	5	0	26	42	16	6
	2	0	6	0	6	13	13	22	40

TABLE 25

Percentage Distributions of the Rating Given to

Task 6 on Each of Thirty-Seven Abilities

Ability	Group	Rating							
		0	1	2	3	4	5	6	7
1. Verbal Comprehension	1	47	11	31	11	0	0	0	0
	2	36	40	9	5	0	5	5	0
2. Verbal Expression	1	47	6	26	21	0	0	0	0
	2	36	30	5	5	9	5	9	0
3. Ideational Fluency	1	63	5	5	11	5	11	0	0
	2	36	9	5	6	9	13	13	9
4. Originality	1	31	5	11	11	26	0	5	11
	2	22	0	10	14	14	18	9	13
5. Memorization	1	42	5	0	15	26	0	11	0
	2	13	18	5	23	18	9	14	0
6. Problem Sensitivity	1	16	0	26	26	15	12	5	0
	2	5	10	9	27	22	5	22	0
7. Mathematical Reasoning	1	73	16	6	5	0	0	0	0
	2	68	18	0	0	9	0	5	0
8. Number Facility	1	68	16	16	0	0	0	0	0
	2	68	22	5	0	0	0	5	0
9. Deductive Reasoning	1	15	0	36	22	12	5	5	5
	2	9	18	18	13	22	0	14	6
10. Inductive Reasoning	1	31	21	11	21	11	0	0	5
	2	36	13	18	9	9	5	9	0
11. Information Ordering	1	31	12	42	5	5	5	0	0
	2	22	18	9	9	13	9	14	6
12. Category Flexibility	1	52	15	15	6	6	6	0	0
	2	45	9	13	5	13	5	9	0
13. Spatial Orientation	1	15	15	26	12	12	15	0	5
	2	9	5	0	9	9	5	36	27
14. Visualization	1	21	11	26	21	11	5	5	0
	2	18	6	5	9	22	5	22	13
15. Speed of Closure	1	52	11	11	5	11	0	5	5
	2	18	9	5	5	5	27	18	13
16. Flexibility of Closure	1	12	11	11	15	5	36	5	5
	2	22	5	9	13	13	18	14	6
17. Selective Attention	1	31	0	5	11	15	11	15	12
	2	5	0	5	9	18	5	40	18
18. Time Sharing	1	15	0	0	32	22	11	5	15
	2	18	0	14	6	9	13	27	13
19. Perceptual Speed	1	22	0	0	31	21	15	0	11
	2	5	0	5	5	18	9	45	13
20. Static Strength	1	11	36	21	5	11	5	0	11
	2	40	0	18	5	5	5	18	9
21. Explosive Strength	1	0	0	0	22	31	21	11	15
	2	0	0	0	5	5	5	31	54
22. Dynamic Strength	1	5	0	0	0	11	42	11	31
	2	13	5	0	6	9	5	22	40
23. Stamina	1	0	0	0	0	32	6	26	36
	2	0	0	0	5	0	0	32	63
24. Extent Flexibility	1	5	0	0	0	32	36	5	22
	2	0	5	0	6	9	13	36	31

TABLE 25 Cont'd.

Ability	Group	Rating							
			1	2	3	4	5	6	7
25. Dynamic Flexibility	1	0	0	0	5	16	32	16	31
	2	0	0	0	5	0	5	36	54
26. Gross Body Equilibrium	1	0	5	5	15	22	12	26	15
	2	0	5	5	0	9	9	45	27
27. Choice Reaction Time	1	0	0	0	11	31	26	21	11
	2	0	0	0	5	5	18	45	27
28. Reaction Time	1	0	0	0	5	22	36	15	22
	2	5	0	5	0	0	23	31	36
29. Speed of Limb Movement	1	0	0	0	0	26	26	26	22
	2	0	0	0	9	0	5	36	50
30. Wrist Finger Speed	1	0	0	0	11	11	31	26	21
	2	6	0	5	0	18	13	22	36
31. Gross Body Equilibrium	1	0	0	0	6	26	26	26	16
	2	0	0	0	0	5	5	40	50
32. Multilimb Coordination	1	21	0	5	11	26	5	21	11
	2	0	0	0	6	18	13	13	50
33. Finger Dexterity	1	12	0	31	21	11	15	5	5
	2	0	6	5	5	27	22	13	22
34. Manual Dexterity	1	0	0	0	0	58	36	0	6
	2	0	0	0	6	18	5	40	31
35. Arm-Hand Steadiness	1	12	0	5	5	36	15	5	22
	2	0	0	0	9	22	5	27	36
36. Rate Control	1	12	0	5	5	26	15	22	15
	2	22	0	9	5	5	5	18	36
37. Control Precision	1	36	12	11	15	15	5	5	0
	2	41	0	0	9	18	5	9	18

TABLE 26
Means and Standard Deviations for Each of the
Thirty-Seven Ability Scales on Task 1
for Both Groups of Judges

Ability	Group 1		Group 2	
	Mean	S.D.	Mean	S.D.
1. Verbal Comprehension	0.63	0.98	1.28	1.44
2. Verbal Expression	0.32	1.34	0.70	1.57
3. Ideational Fluency	1.37	1.87	1.80	1.92
4. Originality	1.68	1.89	2.22	1.78
5. Memorization	1.58	1.87	2.30	1.57
6. Problem Sensitivity	3.47	1.96	4.05	1.26
7. Mathematical Reasoning	0.37	0.74	0.57	1.12
8. Number Facility	0.47	1.19	0.57	1.16
9. Deductive Reasoning	2.79	1.79	2.77	1.77
10. Inductive Reasoning	1.53	2.30	1.86	2.05
11. Information Ordering	2.05	1.88	3.35	1.75
12. Category Flexibility	0.53	1.23	1.87	1.73
13. Spatial Orientation	2.26	1.29	4.63	1.26
14. Visualization	1.94	1.85	3.52	2.36
15. Speed of Closure	1.74	1.83	3.53	2.15
16. Flexibility of Closure	2.26	2.24	3.85	1.75
17. Selective Attention	4.11	2.05	4.88	0.94
18. Time Sharing	2.68	1.81	3.45	1.87
19. Perceptual Speed	2.74	2.07	4.89	1.00
20. Static Strength	1.53	1.63	2.11	1.81
21. Explosive Strength	1.58	1.50	1.76	1.74
22. Dynamic Strength	0.58	0.94	0.98	1.22
23. Stamina	0.89	1.07	1.22	1.19
24. Extent Flexibility	1.95	1.47	1.82	0.79
25. Dynamic Flexibility	2.58	1.98	2.94	1.64
26. Gross Body Equilibrium	1.21	1.79	1.53	1.39
27. Choice Reaction Time	4.58	1.50	4.83	1.16
28. Reaction Time	4.42	1.57	5.39	0.68
29. Speed of Limb Movement	3.89	1.65	4.66	1.40
30. Wrist Finger Speed	2.68	1.59	4.62	0.67
31. Gross Body Equilibrium	1.11	1.33	2.88	1.70
32. Multilimb Coordination	3.79	1.73	4.50	1.54
33. Finger Dexterity	1.26	0.96	2.65	1.71
34. Manual Dexterity	2.58	1.57	3.76	1.48
35. Arm-Hand Steadiness	2.58	2.03	2.93	1.94
36. Rate Control	3.37	2.08	4.26	1.88
37. Control Precision	3.58	1.60	4.06	1.69

TABLE 27

Means and Standard Deviations for Each of the Thirty-Seven Ability Scales on Task 2 for Both Groups of Judges

Ability	Group 1		Group 2	
	Mean	S.D.	Mean	S.D.
1. Verbal Comprehension	4.36	1.97	5.15	1.88
2. Verbal Expression	4.02	2.04	5.62	1.61
3. Ideational Fluency	2.44	2.36	3.17	2.26
4. Originality	2.46	2.41	2.56	2.51
5. Memorization	3.87	1.19	4.51	1.60
6. Problem Sensitivity	4.29	1.04	4.91	1.52
7. Mathematical Reasoning	5.12	0.99	4.62	1.77
8. Number Facility	4.97	1.44	5.16	1.76
9. Deductive Reasoning	3.88	1.22	3.85	2.04
10. Inductive Reasoning	3.29	2.31	2.99	2.08
11. Information Ordering	4.58	0.73	5.20	1.35
12. Category Flexibility	2.71	2.50	3.13	2.40
13. Spatial Orientation	4.49	1.41	4.85	2.09
14. Visualization	4.73	1.52	5.11	1.93
15. Speed of Closure	2.35	2.61	4.25	2.20
16. Flexibility of Closure	3.17	2.50	4.36	1.79
17. Selective Attention	2.48	2.13	4.95	1.38
18. Time Sharing	5.04	1.10	4.70	1.97
19. Perceptual Speed	4.93	1.82	5.31	0.85
20. Static Strength	0.61	1.66	0.32	0.54
21. Explosive Strength	0.45	1.14	0.26	0.53
22. Dynamic Strength	0.40	0.82	0.14	0.47
23. Stamina	0.52	1.36	1.10	1.67
24. Extent Flexibility	0.90	1.20	0.58	1.13
25. Dynamic Flexibility	0.98	1.55	0.63	1.00
26. Gross Body Equilibrium	0.60	1.47	0.80	1.86
27. Choice Reaction Time	4.71	1.30	4.31	1.71
28. Reaction Time	4.34	1.52	4.47	1.78
29. Speed of Limb Movement	1.47	1.63	1.58	1.99
30. Wrist Finger Speed	1.46	1.84	2.21	2.04
31. Gross Body Equilibrium	0.43	1.14	1.13	2.13
32. Multilimb Coordination	0.78	1.20	2.48	2.67
33. Finger Dexterity	1.12	1.58	2.21	1.79
34. Manual Dexterity	1.40	1.35	2.22	2.34
35. Arm-Hand Steadiness	1.08	1.65	1.72	2.13
36. Rate Control	1.65	2.32	3.51	2.69
37. Control Precision	3.19	2.42	4.59	2.20

TABLE 28

Means and Standard Deviations for Each of the Thirty-Seven Ability Scales on Task 3 for both Groups of Judges

Ability	Group 1		Group 2	
	Mean	S.D.	Mean	S.D.
1. Verbal Comprehension	0.56	0.46	1.14	1.23
2. Verbal Expression	0.58	0.67	0.80	1.08
3. Ideational Fluency	0.65	0.80	0.96	1.13
4. Originality	0.45	0.59	0.89	0.68
5. Memorization	1.89	1.58	2.21	1.63
6. Problem Sensitivity	2.07	0.21	2.22	1.46
7. Mathematical Reasoning	1.01	1.12	1.35	1.11
8. Number Facility	1.05	1.55	1.10	0.86
9. Deductive Reasoning	1.89	0.96	1.86	1.26
10. Inductive Reasoning	1.02	1.09	1.23	0.88
11. Information Ordering	2.19	1.09	2.92	1.07
12. Category Flexibility	0.93	1.19	1.14	1.08
13. Spatial Orientation	1.08	0.62	2.04	1.52
14. Visualization	1.72	1.19	2.78	1.79
15. Speed of Closure	0.70	1.03	2.01	1.67
16. Flexibility of Closure	1.22	0.73	1.43	1.17
17. Selective Attention	2.03	1.63	3.22	1.55
18. Time Sharing	0.84	1.04	0.99	1.34
19. Perceptual Speed	1.90	0.60	2.29	1.22
20. Static Strength	2.40	1.70	2.15	1.70
21. Explosive Strength	2.34	1.58	1.56	1.90
22. Dynamic Strength	1.60	1.69	0.78	1.25
23. Stamina	1.66	2.08	1.55	1.78
24. Extent Flexibility	2.26	1.46	1.34	1.17
25. Dynamic Flexibility	2.05	1.62	2.03	1.71
26. Gross Body Equilibrium	0.72	1.05	0.58	0.86
27. Choice Reaction Time	1.83	1.34	1.38	1.24
28. Reaction Time	1.65	1.10	1.79	1.09
29. Speed of Limb Movement	1.71	1.24	2.39	1.90
30. Wrist Finger Speed	2.34	1.31	3.15	1.44
31. Gross Body Equilibrium	1.29	1.21	1.32	1.37
32. Multilimb Coordination	2.57	1.34	2.66	1.92
33. Finger Dexterity	3.06	1.27	3.87	1.94
34. Manual Dexterity	2.71	1.56	4.10	2.16
35. Arm-Hand Steadiness	3.21	1.71	3.94	2.23
36. Rate Control	1.19	2.03	1.48	1.67
37. Control Precision	2.80	1.55	4.03	1.95

TABLE 29

Means and Standard Deviations for Each of the Thirty-Seven Ability Scales on Task 4 for both Groups of Judges

Ability	Group 1		Group 2	
	Mean	S.D.	Mean	S.D.
1. Verbal Comprehension	3.29	2.87	3.32	2.84
2. Verbal Expression	2.77	2.95	3.08	2.87
3. Ideational Fluency	2.67	2.71	3.00	2.65
4. Originality	2.55	2.57	3.81	2.41
5. Memorization	4.15	2.66	4.74	1.73
6. Problem Sensitivity	4.79	1.69	5.28	1.70
7. Mathematical Reasoning	5.90	0.72	5.88	1.33
8. Number Facility	5.58	1.66	5.46	2.09
9. Deductive Reasoning	3.78	2.24	4.77	1.96
10. Inductive Reasoning	3.16	2.46	3.65	2.27
11. Information Ordering	5.48	1.29	6.09	0.38
12. Category Flexibility	2.26	2.81	3.23	2.35
13. Spatial Orientation	5.69	1.90	5.77	1.66
14. Visualization	5.83	1.36	6.26	0.80
15. Speed of Closure	3.67	2.79	3.91	2.90
16. Flexibility of Closure	3.54	2.76	3.43	2.65
17. Selective Attention	2.69	2.71	4.37	2.19
18. Time Sharing	5.15	2.25	5.36	1.44
19. Perceptual Speed	5.05	1.98	5.29	1.98
20. Static Strength	1.39	1.36	1.01	1.95
21. Explosive Strength	0.60	0.55	0.98	1.69
22. Dynamic Strength	0.66	1.08	0.31	0.48
23. Stamina	1.30	2.09	1.39	1.68
24. Extent Flexibility	1.28	0.87	1.61	1.86
25. Dynamic Flexibility	2.16	2.15	1.36	1.55
26. Gross Body Equilibrium	2.09	2.54	2.48	2.95
27. Choice Reaction Time	5.57	1.95	4.88	2.08
28. Reaction Time	5.35	1.80	4.90	2.03
29. Speed of Limb Movement	3.14	2.05	1.97	1.56
30. Wrist Finger Speed	3.23	2.23	3.14	1.68
31. Gross Body Equilibrium	1.91	2.68	2.01	1.99
32. Multilimb Coordination	2.50	2.71	1.85	2.03
33. Finger Dexterity	2.27	2.57	2.72	1.87
34. Manual Dexterity	2.88	2.41	3.50	2.23
35. Arm-Hand Steadiness	3.33	2.63	3.63	1.90
36. Rate Control	4.64	2.71	4.34	2.72
37. Control Precision	6.67	1.18	5.86	1.91

TABLE 30

Means and Standard Deviations for Each of the Thirty-Seven Ability Scales on Task 5 for Both Groups of Judges

Ability	Group 1		Group 2	
	Mean	S.D.	Mean	S.D.
1. Verbal Comprehension	3.80	1.31	3.74	1.73
2. Verbal Expression	2.88	2.04	2.28	1.93
3. Ideational Fluency	2.14	2.28	2.63	1.84
4. Originality	2.40	1.96	3.26	2.28
5. Memorization	3.69	2.02	4.99	1.16
6. Problem Sensitivity	4.67	1.28	5.51	0.64
7. Mathematical Reasoning	2.94	2.11	2.95	2.06
8. Number Facility	2.56	2.01	2.34	1.93
9. Deductive Reasoning	3.41	1.63	4.44	1.45
10. Inductive Reasoning	2.96	2.19	3.67	1.85
11. Information Ordering	3.81	1.21	4.87	0.68
12. Category Flexibility	2.54	2.39	3.06	2.20
13. Spatial Orientation	4.93	0.98	6.35	0.86
14. Visualization	2.78	1.74	5.47	1.30
15. Speed of Closure	2.61	2.04	4.45	1.97
16. Flexibility of Closure	4.98	1.51	4.61	2.12
17. Selective Attention	3.46	2.28	5.24	0.08
18. Time Sharing	4.53	1.23	4.56	1.10
19. Perceptual Speed	4.42	1.01	5.15	1.10
20. Static Strength	1.97	2.25	2.45	2.00
21. Explosive Strength	1.19	1.71	1.32	1.92
22. Dynamic Strength	1.35	1.68	0.79	1.20
23. Stamina	1.49	1.15	2.06	1.93
24. Extent Flexibility	1.70	0.76	1.80	1.49
25. Dynamic Flexibility	2.32	1.44	3.15	2.36
26. Gross Body Equilibrium	1.21	1.68	2.75	2.18
27. Choice Reaction Time	5.19	0.87	4.81	1.50
28. Reaction Time	4.18	1.13	5.40	0.58
29. Speed of Limb Movement	3.32	1.84	4.54	1.43
30. Wrist Finger Speed	3.22	2.21	4.19	1.36
31. Gross Body Equilibrium	1.26	1.27	3.73	1.98
32. Multilimb Coordination	3.34	1.91	5.04	1.18
33. Finger Dexterity	1.70	1.92	3.21	1.74
34. Manual Dexterity	3.05	2.14	4.66	1.50
35. Arm-Hand Steadiness	3.54	2.29	4.53	1.84
36. Rate Control	4.19	2.05	5.02	1.95
37. Control Precision	4.93	1.02	5.90	0.70

TABLE 31

Means and Standard Deviations for Each of the Thirty-Seven Ability Scales on Task 6 for Both Groups of Judges

Ability	Group 1		Group 2	
	Mean	S.D.	Mean	S.D.
1. Verbal Comprehension	1.25	0.90	1.40	1.44
2. Verbal Expression	1.36	1.12	1.79	1.92
3. Ideational Fluency	1.32	1.75	2.94	2.52
4. Originality	2.81	2.21	3.69	2.18
5. Memorization	2.40	1.95	3.18	1.56
6. Problem Sensitivity	3.04	1.15	3.84	1.07
7. Mathematical Reasoning	0.58	0.79	0.95	1.57
8. Number Facility	0.61	0.72	0.70	1.28
9. Deductive Reasoning	2.92	1.56	3.20	1.65
10. Inductive Reasoning	2.00	1.71	2.08	1.82
11. Information Ordering	1.78	1.15	2.99	2.01
12. Category Flexibility	1.24	1.42	1.96	1.98
13. Spatial Orientation	2.84	1.54	5.29	1.41
14. Visualization	2.41	1.49	4.11	1.96
15. Speed of Closure	1.72	2.08	4.11	2.15
16. Flexibility of Closure	3.79	1.48	3.44	1.95
17. Selective Attention	3.45	2.33	5.28	0.88
18. Time Sharing	3.98	1.65	4.25	2.07
19. Perceptual Speed	3.55	1.67	5.32	0.72
20. Static Strength	2.47	1.96	2.75	2.56
21. Explosive Strength	4.75	1.14	6.33	0.66
22. Dynamic Strength	5.54	1.58	5.04	2.44
23. Stamina	5.76	0.86	6.59	0.59
24. Extent Flexibility	4.98	1.29	5.72	1.17
25. Dynamic Flexibility	5.65	0.47	6.51	0.93
26. Gross Body Equilibrium	4.75	1.56	5.72	1.05
27. Choice Reaction Time	5.17	1.16	6.08	1.23
28. Reaction Time	5.48	0.97	5.93	0.17
29. Speed of Limb Movement	5.60	0.80	6.39	1.10
30. Wrist Finger Speed	5.54	0.49	5.60	1.10
31. Gross Body Equilibrium	5.28	0.83	6.53	1.22
32. Multilimb Coordination	3.91	2.05	6.09	0.96
33. Finger Dexterity	3.25	1.68	5.06	1.12
34. Manual Dexterity	4.69	0.89	5.98	0.99
35. Arm-Hand Steadiness	4.50	1.61	5.80	0.54
36. Rate Control	4.69	1.49	4.59	2.45
37. Control Precision	2.26	1.62	3.31	2.47

Since the percentage distributions for Task 1 which are shown in Table 20 can be considered representative of the data displayed in Tables 20 to 25, the following discussion will be limited to Table 20. In general, most of the percentage distributions are somewhat platykurtic. Such distributions reflect the finding in the intraclass correlation data that large samples of judges are required to achieve substantial scale reliability. This can also be seen in the rather large standard deviations for the scale ratings on Task 1 (Table 26).

In the above discussion of the r_5 data for both groups of judges it was noted that, on approximately one-half of the scales, reliabilities in excess of 0.70 were obtained. In examining the distributions which underly these scales, it can be seen that in approximately one-half of these cases the reliability is due to agreement on a rating of "zero" or on the estimate that the ability was not applicable to the task. Abilities 1 and 2 are examples of high reliability being associated with agreement on a "zero" rating. This same tendency was present in the first pilot study, although in that study the tendency was more marked.

In addition to determining the amount of reliability which could be expected on the individual scales, the data were analyzed to determine the degree of similarity between pairs of ability profiles on each of the tasks. As in the first pilot study, the statistic r_p was used for this purpose. For each of the two samples of judges and on each of the tasks a value of r_p was calculated for every pair of task ability-profiles. For Group 1 there were 171 such possible pairs of profiles on each of the tasks and for Group 2 there were 231 pairs of profiles on each task. Table 32 gives the number of significant positive values of r_p which were found on each of the

tasks. This table also shows the proportion of the total number of relationships which are represented by the significant, positive values of r_p. As compared with the r_p data from the first pilot study (Table 12), the data in Table 32 indicate substantially greater interprofile similarity.

TABLE 32

Number of Significant Positive Relationships Among the Judges on the Six Tasks and the Proportion of the Total Number of Relationships which the Positives Constitute

	Group 1		Group 2	
Task	Number of Positive r_p's	Proportion of Total	Number of Positive r_p's	Proportion of Total
1	81	.47	96	.42
2	98	.57	145	.63
3	46	.27	61	.26
4	69	.40	95	.41
5	36	.21	87	.37
6	127	.74	146	.63

Table 32 can also be examined to determine whether the judges were better able to agree on rating tasks with which they were more familiar. To do this the data from the familiarity rating scales contained in Table 33 needs to be considered. These data were calculated on the pooled judges (n = 41). A comparison of the data in these two tables indicates no strong relationship between familiarity with the task description and amount of agreement or interprofile similarity. Although the judges were most familiar with Task 1 (Automobile driving) both Task 2 (Air traffic controller) and

Task 6 (Basketball game) showed more interprofile agreement. Task 2 ranked rather low in familiarity while Task 6 was second.

TABLE 33

Mean Ratings on the Familiarity Scales for Each of the Task Descriptions

	Task Descriptions					
Familiarity Scales	1	2	3	4	5	6
1. Degree of understanding	6.59	4.55	5.04	3.98	5.05	6.31
2. Completeness of task	6.00	4.66	5.43	5.35	5.30	5.30
3. Clarity of task description	6.22	4.25	5.30	3.76	5.19	5.69
4. Degree of familiarity	6.54	2.33	2.74	2.29	1.98	5.83
5. Degree of experience	6.05	1.44	1.89	1.07	1.22	4.47
6. Degree of proficiency	5.49	0.99	1.59	0.75	0.77	3.99

Discussion and Conclusions

As compared with the data from the first pilot study, the results of the second pilot study indicate an increase in scale reliability and inter-judge agreement. The increase in scale reliability can be noted in the intraclass correlation coefficients for small groups of judges ($r_{\overline{5}}$). In the first pilot study for the three groups of judges 30%, 28%, and 42% of the $r_{\overline{5}}$ values (Table 4) exceeded 0.7 while for the two groups of judges in the second pilot study, these percentages increased to 51% and 49% (Table 18). The impact of this increase in scale reliability can be seen in the substantial increase in inter-judge agreement (Tables 12 and 32). For example, in the first pilot study, Task 2 exhibited the largest proportion of positive significant $r_{\overline{p}}$ values with 0.12 for the AIR judges and 0.13 for the APA judges.

In the second pilot study, these proportions for Task 2 increased to 0.57 and 0.63. Similar increases were present throughout the data from the second pilot study.

Although these reliability and agreement data would not be acceptable in any final form of the TAS, they are quite encouraging concerning the further development of these scales. The results of the second study indicate that, with further development, the creation of a highly reliable instrument is possible.

In the first pilot study, the data and the comments received from the judges provides valuable information as to how to further develop the rating scales. The second study, however, did not provide data or comments which indicated any specific difficulties with the TAS, and, therefore, no specific procedures for future refinements for the TAS were suggested. In general, it would appear that some of the definitions of the abilities are not fully understood by the judges. Also, in some cases, the distinctions between similar abilities are not comprehended with the result that the abilities are confused and used interchangeably.

Some of the future development efforts on the TAS will center around the further refinements of the list of abilities. As was noted earlier in this report, work is needed to develop a meaningful set of ability definitions in the memory area. Both factor-analytic and theoretical sources will have to be consulted to develop a set of memory abilities which can efficiently account for the "types" of memory required for human task performance. The area of sensation also needs development. This area was not covered at all in the list of abilities employed in the second pilot study. However, since the results of the second study were encouraging with respect to the development of the TAS, a major effort is warranted to generate a comprehensive set of sensory abilities and their attendant definitions.

Finally, given that a workable, although not final form of the TAS has been produced, some future effort will be directed at using the instrument to classify tasks found in several selected areas of the human performance. If meaningful groupings of this literature can be achieved, it will provide some preliminary estimates of the validity of classifying human tasks with an abilities-based rating system. In these latter phases of research we will attempt to answer questions such as the following. Do tasks classified as representative of the same abilities show similar results when we examine the effects of specified procedural or training variables or environmental stressors?

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APPENDIX A

Preliminary Developmental Materials:

Initial List of Specific Abilities

List of General Abilities

TABLE 1

Initial List of Specific Abilities

1. VERBAL COMPREHENSION

   The ability to understand meanings of words or ideas.

   EXAMPLE: Vocabulary tests-especially multiple choice and completion types.

2. ASSOCIATIONAL FLUENCY

   Common to tasks requiring the production of many single and isolated words appropriate in meaning to a given idea in limited time.

   EXAMPLE: Produce as many words opposite in meaning to the word LARGE in two minutes.

3. WORD FLUENCY

   The ability to produce many isolated words that contain one or more structural, essentially phonetic, restrictions, without reference to the meanings of words.

   EXAMPLE: Produce as many words as possible ending with the letters IAN.

4. MEMORY SPAN

   Common to tasks requiring perfect recall for immediate reproduction of an item series after only one presentation of that series. It is important to recall both the specific items as well as the order of the item listing. This ability is strongest on letter and digit span tasks, but also applies to syllables and words as units of information. Mode of presentation may be either visual or auditory. Requiring responses in reverse order to that originally presented seems to make little difference.

   EXAMPLE: After hearing a series of letters or numbers read aloud, reproduce this series exactly.

5. ASSOCIATIVE MEMORY - MEANINGFUL PAIRINGS

   Common to tasks which require recognition of specific relationships between pairs of items, followed by their application to formulation of new pairs.

   EXAMPLE: What is the relationship between each first and last name in this set: SAM MARTIN, TOM MCTAVISH AND PAM MERTON. Apply this principle to combine TIM with either SMITH or MENSCH.

TABLE 1 Cont'd.

6. ASSOCIATIVE MEMORY - ARBITRARY PAIRINGS

Common to tasks which require the immediate recall or reproduction of items of information arbitrarily paired. It is important to learn particular item pairs; there is no obvious relationship between them.

EXAMPLE: Learn 20 pairs of first and last names so that when the last names are presented in different order, the appropriate first names can be supplied.

7. SYMBOLIC AND SEMANTIC ORDERING

Common to tasks which require the ordering of a given symbolic or semantic information into a meaningful sequence. A goal and/or starting point may or may not be provided. Symbolic information includes numbers and letters. Semantic information includes words, sentences and pictures. This ability is strongest for ordering according to time sequence and somewhat weak on hierarchical ordering.

SYMBOLIC EXAMPLE: State the order for a given set of numeric operations to reach another given number from the starting number in 3 steps.

SEMANTIC EXAMPLE: List the steps in appropriate order to complete a project, e.g., planting a new lawn.

8. IDEATIONAL FLUENCY

The ability to produce many responses appropriate to given requirements in limited time. Emphasis is on quantity of responses rather than quality.

EXAMPLE: Write as many different ideas as possible on the topic "A World Without War".

9. ORIGINALITY

The ability to produce many unusual, remotely-associated, or clever responses to a given idea.

EXAMPLE: List as many clever consequences as possible which could result from the event of everybody suddenly going blind. An unusual response here might be that all previously blind people would become leaders.

10. SEMANTIC SPONTANEOUS FLEXIBILITY

Common to tasks requiring production of many categories of ideas appropriate in meaning to a given idea. A category contains items with common properties. The number of idea categories produced is critical rather than the number of individual ideas.

EXAMPLE: Form as many subclasses for a given list of words as possible using your own criteria for category assignment.

TABLE 1 Cont'd.

11. INDUCTION

The ability to form general concepts that will fit sets of data, the forming and trying out of hypotheses.

EXAMPLE: When presented with 3 groups each containing 3 geometrical figures which are alike according to some rule, discover this rule and assign other figures to the most appropriate group.

12. SYLLOGISTIC REASONING

The ability to proceed from stated premises to their necessary conclusions. There is but one correct solution to each problem.

EXAMPLE: Given the statement "In the mid-Pacific on Buna-Buna, the game of ticky-ticky is played out-of-doors," judge these inferences: A. People in Buna-Buna like to play games; B. Ticky-ticky is a difficult game to play; C. There is an island called Buna-Buna.

13. GENERAL REASONING

Common to tasks requiring problem solution. In previous research, deduction has been considered a major aspect of problem solving. Guilford views the understanding or structuring of the problem as critical rather than any type of deduction. Problems can be of a wide variety including those of a mathematical nature.

EXAMPLE: Use knowledge of a ship's position with respect to a port, wind direction, ocean current, and direction of heading to compute effective distance to port following certain rules.

14. NUMBER FACILITY

The ability to accurately manipulate numbers in arithmetic operations rapidly.

EXAMPLE: Add, subtract, multiply or divided a series of numbers.

15. PROBLEM SENSITIVITY

Common to tasks requiring anticipation or sensitivity to the needs or the consequences of a given situation in meaningful terms. One must decide what implications arise from the given information. Needs or consequences are usually multiple. Needs include addition of details to make a given outlined program work and the raising of relevant questions, the answers to which would help solve a given problem. Consequences include forecast of future events based on given information and ways of accomplishing a given goal when provided with certain resources. Seeing what is wrong or what difficulties may arise from given information is also included.

EXAMPLE: If more girls than boys have been born in the last 5 years, what effects can you predict 20 years hence if the trend continues?

16. SPEED OF CLOSURE

Common to tasks requiring rapid identification of visual images presented under unfavorable conditions such as mutilation of words or objects peripherally flashed letters, dim letters after bright stimulation.

EXAMPLE: Identify the number flashed briefly on the screen.

17. PERCEPTUAL SPEED

Common to tasks requiring quick and accurate judgment of figural and symbolic information as to similarity or diversity. Such decisions are based on minor aspects of the information.

FIGURAL EXAMPLE: A large aerial photograph of a city with a small number of circular patches taken from that same view alongside it are to be matched with lettered locations within the complete photograph.

SYMBOLIC EXAMPLE: Inspect pairs of multi-digit numbers and indicate whether the 2 numbers in each pair are the same or different.

18. SPATIAL ORIENTATION

The ability to comprehend arrangements and positions of visual objects in space. The observer is the reference point in space. May also include kinesthetic patterns e.g., right-left discrimination.

EXAMPLE: Given compass and artificial horizon settings for a plane in flight, determine the position of that plane.

19. SPATIAL SCANNING

The ability to select the one best series of steps from all given steps to be taken to achieve a given goal. This process necessitates rapid visual exploration of a wide or complicated spatial field in order to forsee consequences for each step taken. This process may be considered visual planning. For illustration of the process, finding ones way through a paper maze requires quick scanning of the field for openings following paths with the eye and quickly rejecting false leads.

EXAMPLE: Visually trace an electrical circuit diagram with overlapping wires and indicate which pairs of terminals should be attacked to the battery to make it work.

TABLE 1 Cont'd.

20. VISUALIZATION

Common to tasks which require formation of mental images of figures or objects as they will appear after certain changes, such as unfolding or rotation. The observer seems removed from the stimulus pattern in that he appears to manipulate and alter its image. Appropriate responses may be either drawn or selected from given alternatives.

EXAMPLE: A piece of paper folded 2 times has a hole punched through it. How would the sheet look when fully opened?

21. AUDITORY PERCEPTUAL SPEED

The ability to distinguish among various symbolic (code, number) auditory patterns, rapidly.

EXAMPLE: A series of dots and dashes is presented. How many dots are in the run?

22. AUDITORY RHYTHM DISCRIMINATION

Common to tasks requiring distinction among various rhythms, tunes and melodies.

EXAMPLE: Decide whether 2 rhythmic patterns presented in immediate succession are the same or different.

23. ARM - HAND STEADINESS

The ability to make precise arm-hand positioning movements where strength and speed are minimized. It extends to tasks which require steadiness during movement as well as those which require a minimum of tremor during maintenance of a steady arm position.

EXAMPLE: Sight a target with a gun.

24. CONTROL PRECISION

The ability to make fine, highly controlled, but not over-controlled, muscular adjustments, primarily where larger muscle groups are involved. Most critical where adjustments must be rapid but precise. Adjustments are made to visual stimuli and can involve arm-hand or leg.

EXAMPLE: Steer a car through an obstacle course.

25. AIMING

Common to tasks which require the placing of dots in very small circles where there are a large number of circles and the task is highly speeded.

26. FINGER DEXTERITY

The ability to make skillful, controlled manipulations of tiny objects, involving primarily the fingers.

EXAMPLE: Assemble peg, washer, collar units and insert them in small holes.

TABLE 1 Cont'd.

27. MANUAL DEXTERITY

The ability to make skillful, well-controlled (directed) arm-hand movements in manipulating fairly large objects under speeded conditions.

EXAMPLE: As boxes pass by on a conveyor belt, put 2 cans in each.

28. MULTILUMB COORDINATION

The ability to coordinate the movement of a number of limbs simultaneously. Best measured by devices involving multiple controls. (Hands, feet, or hands and feet)

EXAMPLE: Operate the clutch and accelerator pedals on a car.

29. RATE CONTROL

Involves the timing of continuous anticipatory motor adjustments relative to changes in speed and direction of a continuously moving target or object. Actual motor response to change (rather than verbal estimate, e.g.) is necessary. Extends to tasks involving compensatory as well as following pursuit and to those involving responses to changes in rate.

EXAMPLE: Track a moving target by keeping a circle around a dot which changes in speed and direction of movement.

30. REACTION TIME

The factor represents the speed with which the individual is able to respond to a stimulus when it appears. It is independ of the mode of presentation (auditory or visual) and also of the type of responses required. Response cannot involve alternate choices.

EXAMPLE: Depress a button as soon as possible after a buzzer is sounded.

31. SPEED OF ARM MOVEMENT

The speed with which an individual can make a gross, discrete arm movement where accuracy is not required. There is ample evidence that this factor is independent of the reaction time factor.

EXAMPLE: Using a stylus, touch a series of targets in rapid succession.

32. RESPONSE ORIENTATION

This factor has been found general to visual discrimination reaction tasks involving rapid directional discrimination and orientation of movement. It appears to involve the ability to select the correct movement in relation to a given stimulus, especially under highly speeded condition.

EXAMPLE: Flip a particular combination of 2 switches (of 4 available) in response to a light appearing randomly in one of 4 locations on a grid.

TABLE 1 Cont'd.

33. WRIST - FINGER SPEED

The ability to make rapid pendular (back and forth) and/or rotary wrist movements involving rapid, repetitive jabbing movements in which accuracy is not critical. This ability does not depend upon precise eye-hand coordination.

EXAMPLE: Tap alternately on two plates (separated by several inches) as rapidly as possible.

34. KINESTHETIC DISCRIMINATION

The ability to adjust to an upright position in the absence of visual cues, or in the presence of conflicting or confusing visual cues.

EXAMPLE: Adjust a tilted chair to an upright position while wearing a blindfold.

35. ATTENTION

The ability to perform a task in the presence of distraction or interference without a significant loss of efficiency. The ability to concentrate exclusively on the task being performed.

EXAMPLE: Read aloud in the presence of randomly occurring noise bursts.

36. DEPTH PERCEPTION

The ability to accurately judge distances of objects from a specified point.

EXAMPLE: Determine which of two objects is further away or estimate the distance of one or both.

37. COLOR DISCRIMINATION

The ability to distinguish differences in color (hue) or to label colors accurately. The differences in colors being compared or labeled may be small.

EXAMPLE: Sort a variety of color samples into piles according to the primary color they are closest to.

38. NEAR VISUAL ACUITY

The ability to distinguish fine detail in real objects or printed or graphic material. The objects or materials are at arms length or closer to the viewer.

EXAMPLE: Determine if a given stimulus consits of 2 lines separated by a small space or one wide line.

39. FAR VISUAL ACUITY

Same as for near visual acuity except that the stimuli are at a greater distance from the viewer (i.e., greater than arms length away).

TABLE 1 Cont'd.

40. TIME SHARING

The ability to obtain and utilize information presented within more than one visual display. (Operator must be at least 30 inches from the console and the displays must be separated by at least 16 inches.)

EXAMPLE: Driving a car into a sharp curve, determine which gear is appropriate by checking tachometer while also observing position on the road.

41. EXPLOSIVE STRENGTH

Common to tasks which require expenditure of a maximum of energy in one or a series of explosive acts. This factor emphasizes the mobilization of energy for a burst of effort, rather than continuous strain, stress or repeated exertion of muscles.

EXAMPLE: Throw a softball as far as possible without moving your feet.

42. STATIC STRENGTH

Common to tasks which require the exertion of a maximum strength against a fairly immovable external object even for a brief period. It is general to different muscle groups (hand, arm, back, shoulder, legs) and to different kinds of tasks.

EXAMPLE: Squeeze a grip dynamometer as hard as possible.

43. DYNAMIC STRENGTH

The ability to exert muscular force repeatedly or continuously over time. It represents muscular endurance and emphasizes the resistance of the muscles to fatigue. Tests loaded on this factor tend to emphasize the power of the muscles to propel, support or move the body repeatedly or to support it for long periods.

EXAMPLE: Perform as many sit-ups as possible.

44. EXTENT FLEXIBILITY

The ability to extend or stretch the body. Tests which load on this factor require stretching of the trunk and back muscles as far as possible, without speed, either laterally, forward or backward.

EXAMPLE: Twist as far around as possible touching scale on the wall.

45. DYNAMIC FLEXIBILITY

Common to tasks which require rapid and repeated trunk and/or limb movements. Emphasizes both speed and flexibility.

EXAMPLE: Without moving your feet, as rapidly as possible, bend and touch a spot on the floor, stand up, twist and touch a spot on the wall behind.

46. GROSS BODY EQUILIBRIUM

Defined by balance tests involving maintenance of body equilibrium.

EXAMPLE: With your eyes closed and your hands on your hips, balance on one foot.

TABLE 1 Cont'd.

47. GROSS BODY COORDINATION

The ability to perform a number of body movements simultaneously.

EXAMPLE: Holding the ends of a short rope in each hand, jump over the rope without tripping, falling or releasing the rope.

48. STAMINA (CARDIOVASCULAR ENDURANCE)

The ability to extend a maximum amount of exertion with the entire body over a prolonged period of time.

EXAMPLE: Run a distance of one mile as fast as possible.

TABLE 2

List of General Abilities

1. COGNITION

   Awareness, immediate discovery or rediscovery, or recognition of information in various forms such as figures, symbols or words; comprehension or understanding.

2. MEMORY

   Retention or storage, with some degree of availability, of information in the same form it was committed to storage and in response to the same cues in connection with which it was learned.

3. DIVERGENT PRODUCTION

   Generation of information from given information, where the emphasis is upon variety and quantity of output from the same source. Likely to involve transfer, that is, recall of information by cues not originally associated with the information. Generally, the type of problem requiring this activity has few restrictions allowing for a broad search for relevant information. The output is in quantity and the criteria for success are vague, somewhat lax, and may stress variety and quantity. Examples of such problems are the production of many titles for a given short story or the production of many words opposite in meaning to a given word. This ability is most clearly involved in aptitudes of creative potential.

4. CONVERGENT PRODUCTION

   Generation of information from given information, where the emphasis is upon achieving unique or conventionally accepted best outcomes. It is likely that the given (cue) information fully determines the response. Generally, the type of problem requiring this activity is well structured so that the search for relevant information is narrow. Output is limited and the criteria for success is sharper, more rigorous and demanding. Examples of such problems are deciding upon an appropriate name or summarixing word for any given information or ordering information into a meaningful sequence.

5. EVALUATION

   Comparison of two or more items of given information based on stated criteria resulting in a decision concerning degree of criteria satisfaction. Criteria may include identity, similarity and con-consistency. Comparison of a single item of information with past experience on similar items according to stated criteria resulting in a decision about degree of criteria satisfaction. Criteria can include correctness, suitability, adequacy and desirability.

TABLE 2 Cont'd.

6. PRECISION

The ability to make fine, well-controlled movements or muscular adjustments involving the arms and/or hands. Includes maintenance of steadiness during movement or a steadiness during movement or a steadiness of position.

7. DEXTERITY

The ability to make skillful, controlled manipulations of either the arms, hands or fingers in handling objects of various sizes.

8. SPEED OF MOVEMENT

The ability to make rapid, discrete movements where accuracy or precision are not required. Movements may involve the arm, hand or fingers. The critical component of this ability is speed.

9. COORDINATION

The ability to coordinate the movement of a number of limbs simultaneously or the body as a whole. Also includes maintenance or achievement of balance or equilibrium.

10. MOVEMENT DISCRIMINATION

The ability to select the correct movement from several alternatives or to adjust movement (speed and/or direction) in response to changes in a moving stimulus or target.

11. STRENGTH

The ability to exert a maximum amount of force with any part of the body for a given period of time. The effort may be continuous or in repeating bursts.

12. FLEXIBILITY

The ability to stretch, twist, or rotate the body. The movement may involve speed such as in rapid alternation or change of direction or it may involve movement to limits (e.g., bend backwards as far as possible).

APPENDIX B

First Pilot Study Materials:

Rating Instructions

Task Assessment Scales

Task Descriptions

Answer Sheets

INSTRUCTIONS

Background

The purpose of the present study is to investigate a method of analyzing task performance using a list of defined human "abilities" as task descriptors. An ability is defined as a general trait or capacity of an individual to perform a number of specific activities. Each individual possesses a set of abilities which, when taken together, may account for his overall performance capacity.

It may be helpful to think of abilities as analogous to the notions of traits or talents. It is often the case that a particular person is thought of as "athletic" or "musically inclined." However, the abilities isolated so far, are more carefully delineated than this in describing man's performance potential.

The list of abilities enclosed can be used to analyze any task (simple to complex) in terms of the types of performance capacities which would be required. The performance of any given task may require the presence of one or more of these abilities. Furthermore, the levels of the abilities involved would probably be different. The individual who possesses a higher level of these necessary abilities would theoretically perform better on the given task than the individual who exhibits a lower amount of these same abilities. The basic notions here are: 1) A task can be defined in terms of the abilities required to perform it; and 2) Assuming individuals can be tested for each of these abilities, that individual who possesses the specified abilities to the greatest extent would be predicted as the one who would best perform the task.

Procedure

Included in the kit of materials you have received is a background information card which we would like you to fill out. This card is followed by three task descriptions selected from the experimental and/or task analysis literature. The task descriptions are numbered 1 through 3. Please observe this order when reviewing them. Each task description is followed by a set of answer sheets for each task. The final item included in your kit of materials is the Ability Description Form which contains the definitions for 50 different abilities.

Now look at the first set of answer sheets. You will notice 3 columns. The first column contains the labels of all the abilities in the same order as they appear on the Ability Description Form. The second and third columns are to be filled out by you. The degree of importance of each ability for the task you have just read is based on a 3 point scale which is defined as follows:

0 - Not Involved:	The ability is not at all involved in the performance of the task.
1 - Base-Line:	The ability is required in the task, but it does not contribute to individual differences in performance. This may be thought of as a "base-line" level of ability, that is, the "average" person would exhibit the amount of ability required.
2 - Critical:	The ability is involved in the task and it does contribute to individual differences in performance. This may be thought of as above a base-line level of ability, that is, the average person does not exhibit the amount of ability required to perform the task. The task requires a high degree of this ability.

Please read the first ability description on the Ability Description Form. Decide whether or not the ability as defined is required in performance of the task you just read. Caution: Please note that the "names" attached to each ability definition (e.g., Verbal Comprehension) are provided only as convenient labels. It is important that you use the definition for each ability as stated rather than any definition which you might have from previous experience with these labels in other contexts. If the ability is involved, decide to what extent it is required. Then write down the number (0, 1, 2) you feel is most appropriate in the column headed "Degree of Importance." Continue through the remaining ability descriptions in this fashion, thus completing Column 2.

In the last column, rank from highest to lowest (1 to N), those abilities you indicated as critical for this task in terms of their relative contribution to good performance. That is, if you select a person for this task with only one above average (critical) level of an ability, which ability would you most want him to have? Assign that ability #1 in Column 3. If you could select a person with the first critical ability and one other above average level ability, what second ability do you feel he should have? Assign that ability #2. Continue in this manner, assigning the appropriate number to each of your listed critical abilities. Then answer the two questions at the bottom of the page.

Proceed in this fashion through the remaining two tasks.

Please return all materials in the self-addressed envelope to:

American Institutes for Research
8555 Sixteenth Street
Silver Spring, Maryland 20910

ABILITY DESCRIPTION FORM

1. VERBAL COMPREHENSION

The ability to understand meanings of words or ideas. This ability involves more precise knowledge of exact meanings or distinctions between fine shadi ngs of meaning as well as breadth of knowledge of less familiar wo rds or ideas.

EXAMPLES: (1) Pick the word from the following which is closest in meaning to the word HARBINGER: (a) forerunner (b) well-tailored (c) fortune teller (d) port

(2) Given the word LAMP, which of these alternatives is closest in meaning: TORCH, BURNER, CANDLE, LANTERN?

2. ASSOCIATIONAL FLUENCY

Common to tasks requiring the production of many single and isolated words appropriate in meaning to a given word or idea increases the scope of possible words which can be appropriate.

EXAMPLES: (1) Produce as many words as possible opposite in meaning to the word LARGE in 2 minutes.

(2) Fill in the blank in the follow ing sentence with as many alternate words as you can think of in 3 minutes: HIS SMILE IS AS WIDE AS A (N)_____.

3. WORD FLUENCY

The ability to produce many isolated words that contain one or more structural, essentially phonetic, restrictions, without reference to the meanings of words. As the number or kind of specifications become more restrictive (e.g., specifying more than 2 letters or requiring production of words that rhyme with a given word), loading in this factor decreses while loading on VERBAL COMPREHENSION increases.

EXAMPLES: (1) Produce as many words as possible ending with the letters CK.

(2) Produce as many words as possible that begin with the letter D and end with the letter E.

4. SERIAL RECALL

The ability to recall and reproduce a series of items after one or more presentations of that series. It is important to recall both the specific items as well as the order of the items in the list. This ability is strongest on letter and digit span tasks, but also applies to syllables and words as units of information. Mode of presentation may be either visual or auditory. Requiring responses in reverse order to that originally presented seems to make little difference.

EXAMPLES: (1) After hearing a series of letters read aloud, reproduce this series exactly.

(2) Recall a phone number after looking it up in the telephone directory.

5. FREE RECALL

The ability to recall and reproduce a series of items after one or more presentations of that series. It is important to recall the specific items in the list, but they need not be recalled in any particular order. Mode of presentation may be either visual or auditory.

EXAMPLE: (1) After hearing a series of letters read aloud, recall all the letters in any order.

6. PAIRED ASSOCIATE MEMORY

Common to taks which require the recall or reproduction of items of information arbitrarily paired. It is important to learn particular item groupings. There is no obvious relationship between the members of a pair and no logical way of getting from one pair member to the other except by rote memory.

EXAMPLE: (1) Learn 20 pairs of first and last names so that when the last names are presented in different order, the appropriate first names can be supplied.

7. MEMORY FOR OPERATIONS

The ability to remember logical connections or meaningful relationships among previously learned items of information (e.g., mathematical formulas, operating procedures).

EXAMPLES: (1) Choose word pairs that have the same sense-direction relationships as the ones given on a previously studied page.

Sample Study Item:	Sample Test Item: Highway
Alley-Highway	A. Lion-Kitten
	B. Creek-River
	C. Boat-River
	D. Track-Train

(2) A doctor examining a patient determines the type of illness by relating the symptoms of the patient to knowledge of various disease symptoms.

8. MEMORY FOR IDEAS

The ability to recall the essence of previous studied material (e.g., the main point or topic of a paragrah). Rote recall of this material (e.g., specific words or sentences) is not required. Responses may be either written or oral.

EXAMPLES: (1) List the main ideas in the short story you just finished reading.

(2) Present a prepared speech without the use of notes.

9. SYMBOLIC AND SEMANTIC ORDERING

Common totasks which require the ordering of given symbolic or semantic information into the most meaningful or best sequence. A starting point and/or goal may or may not be provided. Symbolic information includes numbers, letters and pictures. Semantic

information includes words and sentences. This ability is strongest for ordering according to time sequence and somewhat weak on hierarchical ordering.

SYMBOLIC EXAMPLE: State the order for a given set of numeric operations to reach another given number from the starting number in 3 steps.
e.g., Given the number 6, order the following three operations so that the number 18 would be obtained. A 3
B + 2
C x 3

SEMANTIC EXAMPLE: Given a series of steps to complete a project, e.g., planting a lawn, determine the best order to complete this project.

10. IDEATIONAL FLUENCY

The ability to produce many verbal responses appropriate to given requirements in limited time. Emphasis is on quantity of responses rather than quality. Types of activities which involve this ability are: production of ideas appropriate to a given topic or theme, production of titles appropriate to a given story or article, and naming of objects which meet one or more specifications. In this last instance, this ability is strongest for 2 specifications, fairly strong for 1, and becomes weaker as specifications increase beyond 2.

EXAMPLES: (1) Write as many different ideas as possible on the topic A WORLD WITHOUT WAR. (A time limit of 10-15 minutes is specified).
(2) Name as many objects as you can that are ROUND AND WHITE.

11. ORIGINALITY

The ability to produce many unusual, remotely-associated, or clever responses to a single given idea. The ability to improvise procedures in an unusual situation where standard operating procedures do not apply.

EXAMPLE: List as many clever consequences as possible which could result from the event of everybody suddenly going blind. An unusual response here might be that all previously blind people would become leaders.

12. CATEGORY FLEXIBILITY

Common to tasks requiring production of many categories of ideas appropriate in meaning to a given idea or situation where there are a large number of possible responses. A category contains at least 2 items with some common property to be determined by the individual. The number of idea categories produced is critical rather than the number of individual ideas.

13. INDUCTION

The ability to find general concepts that will fit sets of data, the forming and trying out of hypotheses.

EXAMPLES: (1) When presented with 3 groups each containing 3 geometrical figures which are alike according to some rule, discover this rule and assign other figures to the most appropriate group.

(2) Given this number series: 1, 2, 4, 7, 11 - pick the number from the following which follows the rule for this series and should appear in the blank: a) 12 b) 14 c) 16 d) 17

14. SYLLOGISTIC REASONING

The ability to proceed from stated premises to their necessary conclusions. Of the alternative conclusions possible, only one can most adequately be drawn based on the information provided in the premise(s).

EXAMPLES: (1) Given the statement: In the mid-Pacific, on Buna-Buna, the game of ticky-ticky is played out of doors, choose the best inference from those which follow: A. People in Buna-Buna like to play games; B. Ticky-Ticky is a difficult game to play; C. There is an island called Buna-Buna.

(2) Given these statements: No A are B; All A are C, choose the correct inference from those which follow: a) Some C are B; b) Not all C are B; c) Not all B are C; d) Some that are B are C.

15. ARITHMETIC REASONING

Common to tasks requiring the understanding or structuring of arithmetic word problems. This process involves a decision as to what operations must be performed to solve a problem. A decision as to what, if any, additional information is required to reach a solution may also be necessary. There is but one correct solution to each problem. Actual manipulation of numbers is <u>not</u> included here.

EXAMPLE: A rectangular tank is being built to hold water. It is to be 5' high and 9' long. How many cubic feet of water will it hold? a) Given the formula for volume you decide that the additional information needed here is width of the tank. b) If the width is 46", then the operations necessary to solve this problem are to make all dimensions either inches or feet and then multiply the three dimensions together.

16. NUMBER FACILITY

The ability to accurately and rapidly manipulate numbers in arithmetic operations.

EXAMPLE: Add, subtract, multiply or divide a series of numbers.

17. PROBLEM SENSITIVITY

Common to tasks requiring anticipation or sensitivity to the needs or the consequences of a given situation in meaningful terms. One must decide what implications arise from the given information. Needs or consequences are usually multiple. Needs include addition of details to make a given outlined program work and the raising of relevant questions, the answers to which would aid in the selection of an appropriate solution to a given problem. Consequences include forecast of future events based on given information and ways of accomplishing a given goal when provided with certain resources. Seeing what is wrong or what difficulties may arise from given information is also included. This ability does not extend to mathematical considerations.

EXAMPLES: (1) If more girls than boys have been born in the last 5 years, what effect can you predict 20 years hence if the trend continues?

(2) List at least 4 things you would take into consideration in selecting the site for a hamburger stand you plan to build.

18. FLEXIBILITY OF CLOSURE

The ability to perceive or detect the relevant stimulus (previously specified) in the presence of distracting materials or "noise". The stimulus can be either visual or auditory.

EXAMPLES: (1) Find all the words containing the letter "A" in this list of 40 words.

(2) Detect targets of interest when they appear on a radar scope.

(3) Determine if a given pattern of sounds includes the relevant coded stimulus.

19. PERCEPTUAL SPEED

Common to tasks requiring quick and accurate judgment as to whether or not 2 items of figural or symbolic information are exactly the same. Such decisions are based on fine distinctions between similar items of information.

FIGURAL EXAMPLE: Circular patches taken from a large aerial photograph of a city are to be matched with lettered locations within a complete photograph of the same view.

SYMBOLIC EXAMPLE: Inspect pairs of multi-digit numbers and indicate whether the numbers in each pair are the same or different.

20. SPATIAL ORIENTATION

The ability to comprehend arrangements and positions of visual objects in space. The observer is the frame of reference. Also include kinesthetic patterns, e.g., right-left discrimination.

EXAMPLES: (1) Given compass and artificial horizon settings for a plane in flight, followed by 5 photographs showing an airplane in 5 different positions, choose the picture which agrees with the two instrument readings.

(2) A series of hands are pictured in different positions. Decide whether each hand shown is the right or left. (Usually, the individual uses his own hands to match the positions shown in the pictures.)

21. SPATIAL SCANNING

The ability to select the one best series of steps from all possible steps to be taken to achieve a given goal. This process necessitates rapid visual exploration of a wide or complicated spatial field in order to foresee consequences for each step taken. This process may be considered visual planning. For illustration of the process, finding ones way through a paper maze requires quick scanning of the field for openings, following paths with the eye, and quickly rejecting false leads.

EXAMPLE: Visually trace an electrical circuit diagram with overlapping wires and indicate which pairs of terminals should be attached to the battery to make it work.

22. VI[illegible]ALIZATION

Common to tasks which require formation of mental images of figures or objects as they will appear after certain changes, such as unfolding, rotation or movement of some type. The observer seems removed from the stimulus pattern in that he appears to manipulate and alter its image. Appropriate responses may be either sketched or selected from given alternatives.

EXAMPLE: A piece of paper folded 2 times has a hole punched through it. How would the sheet look when fully opened?

23. AUDITORY PERCEPTUAL SPEED

The ability to distinguish among various symbolic (code, number) auditory patterns, rapidly.

EXAMPLES: (1) A series of dots and dashes is presented. How many dots are in the run?

(2) A series of numbers are rapidly read aloud. Write them down accurately without falling behind.

24. AUDITORY RHYTHM DISCRIMINATION

Common to tasks requiring distinction among various rhythms, tunes and melodies.

EXAMPLE: Decide whether 2 rhythmic patterns presented in immediate succession are the same or different.

25. ARM - HAND STEADINESS

The ability to make precise arm-hand positioning movements where strength and speed are minimized. It extends to tasks which require steadiness during movement as well as those which require a minimum of tremor while maintaining a static arm position.
EXAMPLE: Sight a target with a gun.

26. CONTROL PRECISION

The ability to make fine, highly controlled muscular movements required to adjust the position of a control mechanism. Examples of control mechanisms are joy sticks, levers, pedals and rudders. A series of adjustments may be required, but they need not be performed simultaneously. This ability is most critical where adjustments must be rapid but precise. Adjustments are made to visual stimuli and involve the use of a single limb, either arm-hand or leg.
EXAMPLE: Operate a joy stick to steer an aircraft.

27. FINGER DEXTERITY

The ability to make skillful, controlled manipulations of objects small enough to be handled with the fingers.
EXAMPLE: Assemble peg, washer, collar units and insert them in small holes.

28. MANUAL DEXTERITY

The ability to make skillful, well-directed arm-hand movements in manipulating fairly large objects under speeded conditions.
EXAMPLE: As boxes pass by on a conveyor belt, put 1 can in each.

29. MULTILIMB COORDINATION

The ability to coordinate the movement of a number of limbs simultaneously. Best measured by devices involving multiple controls. (Hands, feet, or hands and feet)
EXAMPLES: (1) Operate the clutch and accelerator pedals on a car.
(2) Ride a bicycle.

30. RATE CONTROL

Involves the timing of continuous anticipatory motor adjustments relative to changes in speed and/or direction of a continuously moving target or object. Actual motor response to change (rather than verbal estimate) is necessary. Extends to tasks involving compensatory as well as following pursuit and to those involving responses to changes in rate.
EXAMPLE: Track a moving target by keeping a circle around a dot which changes in speed and direction of movement.

31. REACTION TIME

This ability represents the speed with which the individual can provide a single motor response to a single stimulus when it appears. It is independent of the mode of presentation (auditory or visual) and also of the type of motor response required. Response cannot involve alternate choices.

32. SPEED OF ARM MOVEMENT

The speed with which an individual can make a gross, discrete arm movement where accuracy is minimized. There is ample evidence that this ability is independent of reaction time.

EXAMPLE: Using a stylus, touch a series of targets in rapid succession.

33. RESPONSE ORIENTATION

This factor has been found general to visual discrimination tasks. These tasks involved rapid recognition of the direction (e.g., North, South, East, West) indicated by a particular visual stimuli (e.g., an arrow) followed by the appropriate motor response chosen from several alternatives. The response may be simple or complex (i.e., push a button and pull a switch vs. push a button). This ability appears to be most critical when the conditions are highly speeded.

EXAMPLE: Flip a particular combination of 2 switches (or 4 available) in response to a light appearing randomly in one of 4 locations on a grid.

34. WRIST - FINGER SPEED

The ability to make rapid pendular (back and forth) and/or rotary wrist movements involving repetitive jabbing where accuracy is not critical. This ability does not depend upon precise eye-hand co-ordination.

EXAMPLE: Tap alternately on two plates (separated by several inches) as rapidly as possible.

35. VERBAL EXPRESSION

The ability to clearly and concisely to communicate one or more ideas to another person or persons. Mode of communication may be either oral or written.

EXAMPLE: By phone, give explicit directions to the tourist so that he can reach his desired destination.

36. ATTENTION

The ability to perform a task in the presence of distraction or interference without a significant loss of efficiency. The ability to concentrate exclusively on the task being performed.

EXAMPLE: Read aloud in the presence of randomly occuring noise bursts.

37. TIME SHARING

The ability to obtain and utilize information presented within more than one visual display. The operator must be at least 30 inches from the console and the displays must be separated by at least 16 inches for this ability to be involved.

EXAMPLE: Driving a car into a sharp curve, determine which gear is appropriate by checking tachometer while also observing position on the road.

38. EXPLOSIVE STRENGTH

Common to tasks which require expenditure of a maximum of energy in one or a series of explosive acts. This factor emphasizes the mobilization of energy for a burst of effort, rather than continuous strain, stress or repeated exertion of muscles.

EXAMPLE: Throw a softball as far as possible without moving your feet.

39. STATIC STRENGTH

Common to tasks which require the exertion of maximum strength against a fairly immovable external object even for a brief period. It is general to different muscle groups (hand, arm, back shoulder, leg) and to different kinds of tasks.

EXAMPLE: Squeeze a grip dynamometer as hard as possible.

40. DYNAMIC STRENGTH

The ability to exert muscular force repeatedly or continuously over time. It represents muscular endurance and emphasizes the resistance of the muscles to fatigue. Tests loading on this factor tend to emphasize the power of the muscles to proper support or move the body repeatedly or to support it for long periods.

EXAMPLE: Perform as many sit-ups as possible.

41. EXTENT FLEXIBILITY

The ability to extend or stretch the body. Tests which load on this factor require stretching of the trunk and back muscles as far as possible, without speed, either laterally, forward or backward.

EXAMPLE: Twist as far around as possible touching the scale on the wall.

42. DYNAMIC FLEXIBILITY

Common to tasks which require rapid and repeated trunk and/or limb movements. Emphasizes both speed and flexibility.

EXAMPLE: Without moving your feet, bend and touch a spot on the floor, stand up, twist and touch a spot on the wall behind as rapidly as possible.

43. GROSS BODY EQUILIBRIUM

The ability to maintain or regain body balance especially in situations where equilibrium is threatened or temporarily lost.

EXAMPLE: With your eyes closed and your hands on your hips, balance on one foot.

44. GROSS BODY COORDINATION

The ability to simultaneously perform movements which involve the entire body.

EXAMPLE: Holding the ends of a short rope in each hand, jump over over the rope without tripping, falling or releasing rope.

45. STAMINA (CARDIOVASCULAR ENDURANCE)

The ability to extend a maximum amount of exertion with the entire body over a prolonged period of time.

EXAMPLE: Run a distance of one mile as fast as you can.

46. DEPTH PERCEPTION

The ability to judge the relative distance of 2 or more objects from the observer. Also, the ability to provide approximate distance of one or more objects from a specified point. In this case, the closer the distance estimate to the actual distance, the higher the ability level.

EXAMPLE: Determine which of two objects is further away or estimate the distance of one or both.

47. COLOR DISCRIMINATION

The ability to distinguish differences in color (hue) where the differences in colors being compared may be small.

EXAMPLE: Sort a variety of color samples into piles according to the primary color they are closest to.

48. NEAR VISUAL ACUITY

The ability to distinguish fine detail in real objects or printed on graphic material. The objects or materials are at arms length or closer to the viewer.

49. FAR VISUAL ACUITY

Same as for near visual acuity except that the stimuli are at a greater distance from the viewer (i.e., greater than arms length away).

50. KINESTHETIC DISCRIMINATION

The ability to adjust to an upright position in the absence of visual cues, or in the presence of conflicting or confusing visual cues.

EXAMPLE: Adjust a tilted chair to an upright position while wearing a blindfold.

TASK DESCRIPTION #1

Apparatus: A polar pursuit tracking device was used in which S held a rigid stylus equipped with a photoelectric cell to track a moving target light. The device was patterned after a prototype originally developed in the Psychology Laboratory at Cornell University and was re-designed by the senior author and constructed by Shaw Laboratories, Syosset, N. Y. S was confronted with a typical rotary pursuit-type display in which the target rotated at 60 rpm. The target was a 3/4" x 3/4" square portion of a lucite disc and was illuminated by a doughnut-type fluorescent fixture mounted underneath its surface. Two sides of the target were in effect segments of two concentric circles of 6.25" and 7.75" in diameter respectively. The remainder of the rotating lucite disc, which was 18" in diameter and 3/16" thick was painted black. A sheet of plate glass 1/4" thick and 20 x 20" square was mounted over the rotating disc. Its rear surface was covered with black masking tape, a 17" diameter portion of which was stripped away to permit the target and a major portion of the black rotating disc to be visible to S. The center of the target area rotated on a 3.5" orbit and generated a total linear distance of 22" per sec.

S's response member consisted of a rigid stylus, in the tip of which was inserted a photoelectric cell which was activated by the light transmitted through the glass plate from the target. The stylus had a corrugated hand grip 3 1/2" long and 1" in diameter, with a stem protruding approximately 4", at the end of which was a 90 degree bend. The length of the bent portion was 1 1/2". The diameter of the stylus tip was 3/8" and the opening into which light was admitted was 3/16" in diameter. S held the stylus horizontally over the glass plate so that the stylus tip pointed downward and was kept perpendicular to the glass plate at all times during performance.

The three stimulus displays consisted of:

1. a standard RP display labelled NOTAF (for no extra guidance) where S received the usual target and background information.

2. an on-target augmented display called ONTAF where the standard display information was augmented by means of a 10 watt "bug" light but manufactured by the General Electric Co. The bulb was mounted in a standard photoflood-type corrugated reflector which was clipped to a stand 4' above and to the rear of the display. The linear distance from the light to the center of the display was 3'3". The light was directed at an angle of approximately 45 degrees to the surface of the display in such a way as to eliminate undesirable reflections. When the light came on, the entire surface was bathed in yellow light. Whenever S was "on-target," activation of the photoelectric circuit caused a relay closure which turned on the yellow light. The time delay between target acquisition and appearance of the light was determined by the inherent delay in the relay closure and the bulb filament warm-up time, which was determined to be 0.150 $\pm$ 0.010 sec.

3. an off-target augmented display called OFTAF, which was identical to ONTAF with the exception that the yellow light came on after S discontinued contact with the target and remained on until the next acquisition.

E's controls consisted of a motor speed control and meter with which to monitor target rotation as well as a stylus sensitivity control which was used to adjust the sensitivity of the photoelectric cell. Sensitivity was adjusted so that S was judged to be "on-target" whenever the center of the stylus aperture passed over the edge of the target.

S's performance was measured by a 0.01 sec. timer with an accuracy of ± 0.005 sec. constructed by the Standard Electric Time Co., and a Sodeco impulse counter which registered the number of target contacts on each trial. Steps were taken to sound-proof the recording apparatus.

Experimental Design and Procedure: The experiment made use of three groups of 15 Ss each. One group was labelled NOTAF and consisted of the control group which received standard visual information. Group OFTAF received off-target AF and Group ONTAF received on-target AF. Testing sessions were conducted over a two-day period and consisted of 21 training trials during the first session and 12 during the second session, one week later, for a total of 33 training trials. Immediately after training during the second session nine transfer trials were administered during which all AF was removed. Trial lengths were 20 sec. each with 20 sec. rests between each trial. One-minute rests were given after each 3-trial block.

Ss in Group OFTAF were told that a yellow light (which was demonstrated) would come on whenever they were off target whereas Ss in Group ONTAF were told it would come on when they were on target. Control Ss (NOTAF) were simply given the standard instruction in which they were told to keep the stylus tip in contract with the moving target to the best of their ability. When Ss began the task, they were given a pair of ear protectors, similar to those used by aircraft ground crews, to supplement the sound-masking steps taken to eliminate auditory cues from the apparatus. They were instructed in the use of the display, and it was demonstrated when they were "on target" and whey they were "off target." They were asked to place the stylus tip on a small marked-off square proximal to the circle of rotation and to keep itthere when the signal "ready" was given. The signal "ready" was given 3 sec. before the signal "begin," and "stop" 20 sec. later. S's performance was recorded for each 20-sec. trial as TOT in hundredths of a second and total number of target contracts.

TASK DESCRIPTION #2

A simulated approach-control task was used in which subjects (Ss) served as radar controllers (RCs) who were responsible for directing aircraft through an approach gate. The approaches were to be effected at a prescribed rate, and two Ss were required to alternate in controlling approaches. That is, the first approach was to be directed by RC_1, the second by RC_2, and then RC_1 assumed responsibility for the third incoming aircraft, and so on.

The RCs delivered instructions to pilots over a voice-communication channel, and the pilots carried out the instructions faithfully and without delay by appropriate manipulation of their consoles. The RC-to-pilot communication protocol required that the RC first identify the pilot and then issue the command, for example, "Bravo one, speed 200 knots"; in return, the pilot was to immediately confirm the command, for example, "Roger, Bravo one, speed 200 knots." The RCs gave only heading and speed commands to the pilots; altitude was intentionally omitted from consideration in order to maintain a reasonable level of task difficulty.

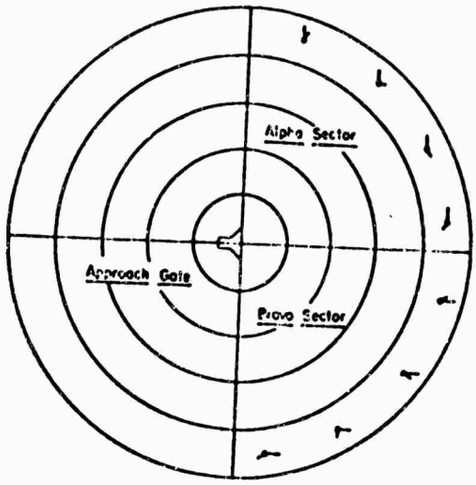

Fig. 1. Reproduction of the display at the start of a session.

The radar display as it appeared at the beginning of a session is reproduced in Figure 1. The approach gate was located precisely at the center of the displayed airspace, and all aircraft entered the airspace from the eastern (right-hand) periphery. The display was marked with the periphery to the approach gate represented 100 miles. The aircraft appearing in the northeast sector of the scope were designated as "Alpha" aircraft, and those appearing in the south east sector were referred to as "Bravo" aircraft. The Alpha and Bravo aircraft were indicated by different codes. The RCs were not allowed to write down the specific codes for any of the planes. The two RCs monitored the same airspace but on different displays, and they could speak to one another only over a voice-communication channel. The Alpha RC was assigned to the Alpha aircraft, the Bravo RC to the Bravo aircraft.

At the beginning of a session, four alpha aircraft were spaced evenly along the eastern periphery of the airspace. An Alpha aircraft made the first approach, a Bravo aircraft followed, then another Alpha aircraft, and so on. A successful approach occurred when an aircraft entered the approach gate at 200 kn. on a heading of 270°. A "miss" occurred if an aircraft in the inner circle of the display crossed the longitudinal axis into the western half of the airspace in any condition not constituting a successful approach.

Within a sector, the planes could fly at any heading specified by the RC as long as the final approach was made at a heading of 270° and a speed of 200 kn. The RCs could do simple computations where necessary to aid them in directing their aircraft. The required approach rate (system criterion) was an approach every 2 min. A compensatory arrangement was employed. That is, a given approach was to compensate for the accumulated time error. Hence, if a time error of 20 sec. late has accrued over prior approaches, the next approach was to be 20 sec. early so that the average of the approach times would equal the system criterion of 2 min.

A clock system was mounted on the wall in front of the team in such a way that the RCs could keep continuous track of their temporal progress in guiding aircraft through the approach gate. Each clock kept time in terms of minutes and seconds up to 1 hour, and could be viewed by only a slight shift in an RCs line of vision from the input display.

The following aspects of the task characterized both team arrangements: (a) A small red light indicated whose turn it was to effect an approach; (b) the timing started upon the completion of the first approach of the session; and (c) immediate feedback was provided to the RC team of time errors (relative to the compensatory or non-compensatory criteria), misses, and safety infractions immediately after each approach except the first.

TASK DESCRIPTION #3

SHEET METAL WORKER: USING HAND LEVER PUNCH

1. Marks point on sheet metal where punch hole is to be made.
2. Selects appropriate punch and die to be used.
3. Unscrews die with screwdriver or key furnished with the punch.
4. Opens punch by lifting lever.
5. Unscrews threaded collar.
6. Lifts punch from collar (if other one is there).
7. Inserts desired punch in collar.
8. Screws on threaded collar.
9. Depresses lever to normal position.
10. Inserts and screws desired die into position.
11. Turns die so that the end of the punch enters the die approximately 1/16" when levers are in normal or closed position.
12. Opens punch.
13. Inserts sheet metal intp punch.
14. Centers punch (centering point of punch is placed in the prick point made during layout).
15. Presses down on lever to punch hole.
16. Opens punch by lifting lever.
17. Visually inspects size and appearance of punched hole.

TASK DESCRIPTION #4

In order to perform the task to be described, it is necessary to understand some orbital dynamics concepts.

See Figure 1.

The first figure shows a space vehicle in orbit around the earth. Orbit 1 is a circular orbit. If a retrograde or slowing down thrust is applied as shown in the figure, elliptical trajectories result. Orbit 2 is such an ellipse. As the vehicle falls toward the earth it gains velocity. The increase in velocity is sufficient to cause it to regain altitude, but as it climbs it slows down again resulting in the elliptic path. Orbit 3 results from enough deceleration to cause the vehicle to re-enter the atmosphere before regaining sufficient velocity to climb.

Now look at the second figure. Orbit 1 is again a circular orbit. The thrust applied as shown would cause the vehicle to accelerate and move into orbit 2. This orbit is also an ellipse, since as the vehicle gains altitude, it slows down and begins to fall. As the vehicle falls it gains velocity and begins to climb as in the first case. If a second thrust is applied at the highest point in the orbit (apogee), shown by the dotted line, orbit 3 is attained. This is a circular orbit higher than orbit 1. This is the most efficient way to change orbits. Thrust is used only twice, the remainder of the time is spent coasting. Similar two-impulse transfers exist for any orbit change.

The purpose of these figures is to show what happens when thrust is applied to an orbiting vehicle.

Now look at figure 3a. The circle with the corss in it represents a vehicle in a circular orbit around the earth. Part of the earth can be seen below the vehicle. The figure is now centered on the vehicle and referenced to an imaginary line between the vehicle and the center of the earth. Thus the earth would appear to turn under the vehicle instead of the vehicle turning about the earth. The situation is exactly the same in Figures 1 and 2, only the view is changed. The dotted box surrounds the area of interest for one type of rendezvous. That is the area ahead of and above and below the target vehicle.

See Figure 3b.

Consider the path of a second vehicle attempting to rendezvous with the target vehicle. If the second vehicle is initially directly ahead of the target at the same altitude and speed (shown in Figure 3b) it must slow down to allow the target to catch up. If the interceptor simply slows up he will lose altitude and follow path 1. This path obviously will not allow him to rendezvous with the target. He must thrust upward to maintain his altitude at the same time that he slows down. If the proper combination of thrusts are applied he might follow path 2. All that would remain for him to do would be to accelerate to the same velocity as the target so that at intercept they would have no (zero) relative velocity.

Each subjects monitors predictor display on a cathode ray tube. It shows you the interceptor]s predicted path for a five minute period. The right hand end of the trace represents the interceptor]s present position. The left hand end represents the interceptor's position five minutes in the future. This trace always represents a five minute prediction. As you accelerate and decelerate the trace will appropriately lengthen and shorten. If the interceptor is stopped relative to the target, the trace will become a dot. The curvature of the trace results from the orbital dynamics, discussed above, operating on the interceptor's velocity vector.

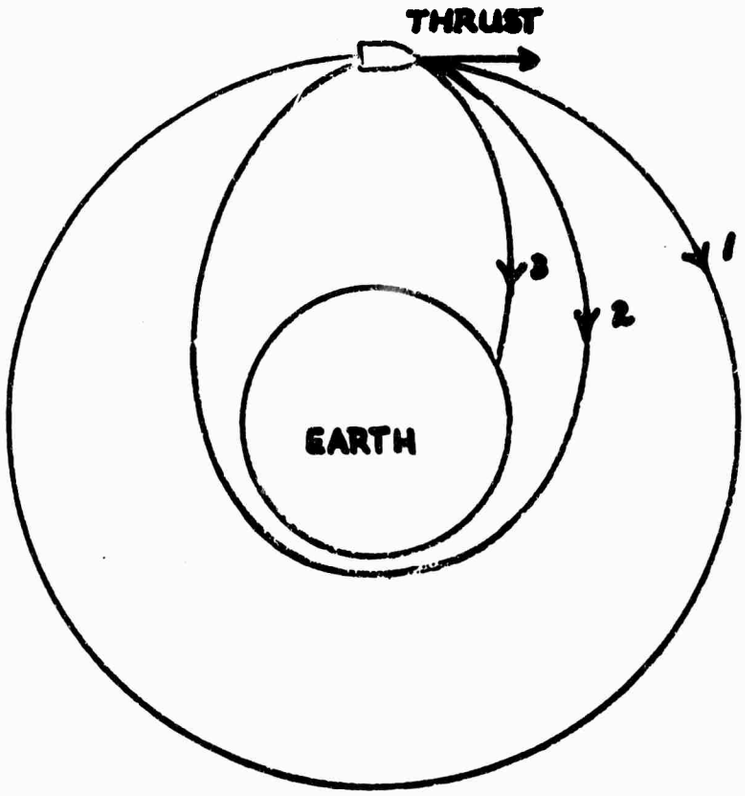

Figure 1

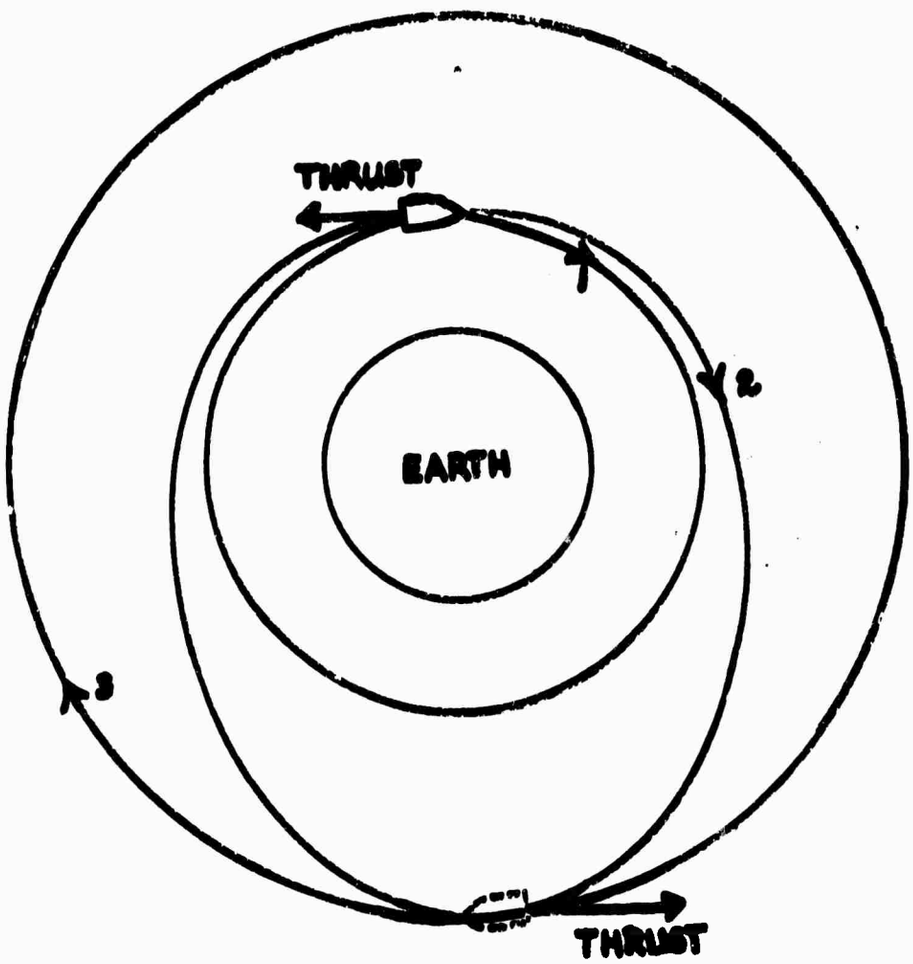

Figure 2

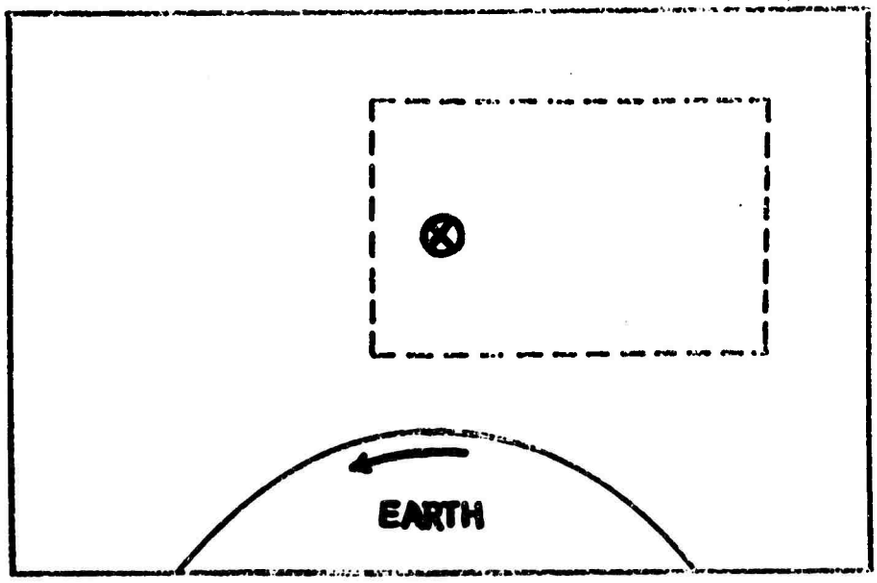

Figure 3a

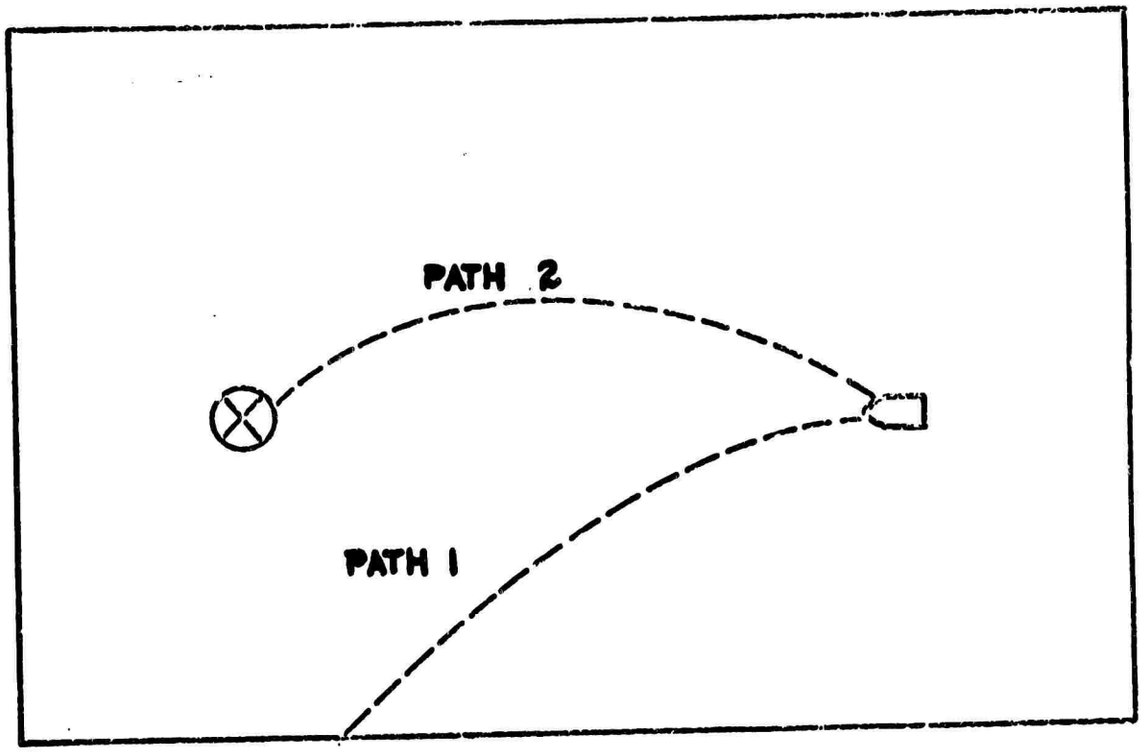

Figure 3b

The dot on the left represents the target vehicle. At the start of each rendezvous maneuver the interceptor will be 80,000 feet ahead and 20,000 feet above the target. The scale on the display is 1 inch = 10,000 feet. The task is to rendezvous with the target within 15 minutes using as little fuel as possible.

At the beginning of each run the initial impulse of a two-impulse transfer has been initiated but not so the subject will coast along the best trajectory. The subject is to correct the orbital path with this controller and continue to "fly" to the target and stop the interceptor at the target. In order to accelerate the interceptor in a specific direction, the subject displaces the control stick in that same direction. The more the stick is displaced the more thrust that is applied. To aid the subject in stopping at the target the scale is expanded when the interceptor gets close to the target. When a range of 10,000 feet is reached (1 inch from the target) the scale will be expanded to 1 inch = 1,000 feet.

The interceptor is to be flown to the target, until the dots touch; then the subject stops the interceptor. He is to use as little fuel as possible and make his rendezvous within 15 minutes.

TASK DESCRIPTION #5

The subjects for this experiment were four experienced pilots with various amounts of helicopter experience. The vehicle used was a Hiller model 12-E, similar to the Army standard primary training helicopter but with an engine of higher horsepower.

The task chosen for the study was a series of four power line patroal missions over terrain unfamiliar to the subjects. Eight flight routes were chosen, each of which required approximately two hours for completion; pilots flow two routes on each experimental day.

Each pilot flew the routes in identical order. After driving to or being flown to a starting point, subjects were given a map showing rural electric power distribution lines, roads and certain other terrain details. A particular line segment, usually about 30 miles in length, was marked in color on the map. The pilot was required to take off, locate the beginning of the line segment to be patrolled, then to fly at slow speed along the line, looking for damaged cross bars, broken insulators or other sources of potential power interruption.

At a point unknown to the subject in advance, the safety pilot who acted as observer pointed out a tap, or terminal distribution line, to the subject, who was required to turn off the mainline and inspect the tap to its end. The subject then pulled up from the line, returned at higher speed to the main line he had left and continued his patrol. Another tap was pointed out during the second hour of flight, again without prior warning.

When the subject completed his first route he proceeded to a nearby airport, landed and refueled. During approximately twenty minutes on the ground he studied his next flight route. After takeoff he again had to find a line, patroal it and inspect another two taps not marked on his map.

The entire flight (except the return from the end of each tap to the line from which it emanated) was conducted at altitudes of from 20 to 50 feet and at lateral distances from the power lines of from 20 to 60 feet. Pilots had to watch for and avoid crossing cables and high tension lines, as well as livestock which are apt to stampede when frightened by helicopters. The power line maps used were unfamiliar to the subjects, as was the terrain. The task thus incorporated a navigation and detailed reconnaisance function, together with intermittent hazards which has to be avoided.

The helicopter was instrumented to allow monitoring of rotor RPM and of the positions of three controls: the collective pitch lever, the throttle, and the cyclic pitch control stick. The collective pitch lever is used to control the pitch on <u>all</u> blades of the rotor, to allow the helicopter to move in an up or down direction. The throttle of the same type as on a motorcycle, is located near the top part of the lever. It provides the power for the engine. In order to lift off, the pilot, using his left hand, pushes the lever forward to increase the pitch while at the same time, he presses on the throttle to provide the necessary power. The cyclic pitch control stick is used to control the pitch of each blade individually, to allow the helicopter to move in any direction other than up or down. The stick is operated with the right hand.

As noted, each subject flew the four missions in the same order. The first and second days of flying were in relatively hilly terrain, whereas the third and fourth days were over generally flat farmland.

TASK DESCRIPTION #6

Subjects

Seventy-two young sailors served as Ss, randomly assigned to four groups of 18.

Visual Stimuli and Task

The display was tilted 25 degrees from the horizontal. Four thousand five hundred letters, randomized by computer, were printed in rows of 10 on paper strip. They moved under a slot which revealed each row for 2 seconds. Average viewing time was 0.2 second per letter. The task was to cross off and count four letters, two at a time, until five of each member of a pair had been achieved, followed by five of each of the other pair, and to continue alternating the sets of two, over a period of 15 minutes.

Auditory Stimuli

The same sound, lasting 1 second, was used for all groups. It contained frequencies in the band 30-6,000 cycles, the major portion of energy being in the lower half. Presentation was through loudspeakers. For N groups, sound-pressure level on the C scale was 105 db; for Q groups it was 68 db.

Procedure

Each man was tested individually, some time between the hours of 1:30 PM and 5:00 PM, in a sound-insulated room. The seated S was first given the appropriate instruction for his group.

Group M_n was told,

> This is a memory experiment. I would like you to look at a list of letters, like this, and search for a number of them. The aim is to find out how well you can memorize the number of letters you need. The letters you are looking for are C, R, X, and J. For for C and R first, and cross off each C and R as you come to them until you have crossed off 5 Cs and 5 Rs. Then leave C and R, and go on to X and J. Cross off 5 Xs and 5 Js. As soon as you have finished X and J, start again immediately with C and R. Go on like that, one pair at a time, alternately, until I tell you to stop, after 15 minutes. The letters rarely come together, for instance when you have 5 of one, you might only have 2 of the other, but don't start on the next pair until you have 5 of each letter in a pair. Always read from left to right. From time to time there is some noise during this test. It's in the form of occasional short bursts of noise, not very loud, but medium loud. Ignore them, don't let them distract you, even for a second, because the idea is not to let anything distract you from the test. I'll let you hear a burst now, before we start, so that you know what it is like.

Group M_q was instructed similarly, except that "quiet sound" was substituted for "noise," with "very quiet" for the qualifying description.

Group S_n was told,

> This is an experiment to see how well you can find particular letters. Here is a list of letters for you to search. Whenever you see one of the letters that are needed, cross it off. Search carefully and try not to miss any.

The letters to look for are C, R, X, and J. To make it less boring, deal with them in pairs, taking C and R as the first pair. After you've found and crossed off 5 Cs and 5 Rs, then start searching for Xs and Js. After finding 5 Xs and 5 Js, go back to C and R, and so on all through the list, alternately, until I tell you to stop, after 15 minutes. Always read from left to right. Do be extremely careful not to miss a letter. The way we mark this test is, by taking away points for every mistake. Each time you miss seeing one of the letters you lose 10 points. Whenever you cross off the wrong number for a set of 5, you lose one point.

Then followed the noise explanation given to M_n. Group S_q was instructed in the same way as S_n, but with the "quiet sound" substitution given to M_q.

Instructions were followed by a single demonstration of the auditory stimulus. The S practiced unpaced for 3 minutes during which the sound occurred twice. The practice run was then marked and shown to S, errors being pointed out and counted - straightforwardly for M groups, by points-penalty system for S groups. The 2-minute paced practice followed, accompanied by one burst of sound. Immediately afterwards S performed the test, during which the sound was presented at minutes: 1/2, 2, 3 1/2, 5 1/2, 6 1/2, 7 1/2, 9 1/2, 10 1/2, 12 1/2, 14.

ANSWER SHEET

Ability	Degree of Importance* 0 = Not involved 1 = Base-line 2 = Critical	Rank*
1. Verbal Comprehension		
2. Associational Fluency		
3. Word Fluency		
4. Serial Recall		
5. Free Recall		
6. Paired Associate Memory		
7. Memory for Operations		
8. Memory for Ideas		
9. Symbolic and Semantic Ordering		
10. Ideational Fluency		
11. Originality		
12. Category Flexibility		
13. Induction		
14. Syllogistic Reasoning		
15. Arithmetic Reasoning		
16. Number Facility		
17. Problem Sensitivity		
18. Flexibility of Closure		
19. Perceptual Speed		
20. Spatial Orientation		
21. Spatial Scanning		
22. Visualization		
23. Auditory Perceptual Speed		
24. Auditory Rhythm Discrimination		
25. Arm-Hand Steadiness		
26. Control Precision		
27. Finger Dexterity		
28. Manual Dexterity		
29. Multilimb Coordination		
30. Rate Control		
31. Reaction Time		
32. Speed of Arm Movement		

*See Instructions: Procedures

Ability	Degree of Importance* 0 = Not involved 1 = Base-line 2 = Critical	Rank*
33. Response Orientation		
34. Wrist-Finger Speed		
35. Verbal Expression		
36. Attention		
37. Time Sharing		
38. Explosive Strength		
39. Static Strength		
40. Dynamic Strength		
41. Extent Flexibility		
42. Dynamic Flexibility		
43. Gross Body Equilibrium		
44. Gross Body Coordination		
45. Stamina (Cardiovascular Endurance)		
46. Depth Perception		
47. Color Discrimination		
48. Near Visual Acuity		
49. Far Visual Acuity		
50. Kinesthetic Discrimination		

*See Instructions: Procedures

(1) Are there any elements of this task which you feel you were unable to analyze using the ability descriptions provided? Yes ____ No ____

a) if yes, please list these task elements.

_____

_____

_____

(2) Are there any elements of other tasks with which you are familiar that cannot be analyzed using these ability descriptions? Yes ____ No ____

a) if yes, please list these task elements.

_____

_____

_____

APPENDIX C

Second Pilot Study Materials:

Rating Instructions

Task Assessment Scales

Task Descriptions

Answer Sheets

INSTRUCTIONS

The kit of materials before you consists of the following items: 1) a reference manual, 2) a set of task descriptions, and 3) a set of answer sheets for each of the task descriptions. You will be asked to analyze each of the task descriptions in terms of the thirty-seven descriptors of human abilities contained in the reference manual. As you analyze a task in terms of each of the abilities, you will mark your ratings of the task on the answer sheets.

In rating the task descriptions you will be making two different decisions. First, you must decide whether the ability, as it is defined in the manual, is required for performance on the task you are rating. Second, if you decide that the ability is required, you must determine the extent or degree to which it is required. The result of your effort will be a quantitative profile of the task in terms of those human abilities required for its performance.

In analyzing the task descriptions the following procedure will be employed.

First, read the task description thoroughly and with extreme care. Be certain that you fully understand all of the activities in which an operator or subject must engage to complete the task. If possible, you should actually attempt to visualize these activities and go through them one by one. When you fully understand the task description, you may begin to analyze it in terms of the abilities in the reference manual.

Second, open your reference manual to pages one and two which contain the first ability descriptor. Begin by reading the material presented on the left-hand page. This page presents the name of the particular ability descriptor, a definition of it, and a chart which distinguishes the ability you are considering from other abilities which are either similar to it or can easily be confused with it. The definition of the ability was developed expressly to present the precise nature of the ability and to reveal its scope and its limits. The chart below the ability definition is presented as a further aid in determining the extent of the ability. This chart is necessary since some abilities differ from each other in only one or two critical aspects and therefore, might easily be confused.

When considering the information presented on this page, it is quite important to focus your attention upon the definition of the ability and upon the chart of distinctions rather than upon the name of the ability. It is quite possible that you have encountered this name in a different context where it had a different meaning. If you focus too much attention upon the name of the ability, this past familiarity with the name will interfere with your rating of the task.

Having considered the information on this page to the point where you completely understand the ability as it is defined, you are ready to make the first decision concerning this ability.

Third, based upon your understanding of the ability you must decide whether this ability is required for performance on the task you are considering. If your decision is NO, check the box marked DOES NOT APPLY on your answer sheet for that ability. Having done this, ignore the right-hand page and proceed to the next ability description and begin your analysis of the task with respect to that description.

If, on the other hand, you decide that some amount of this ability is required for performance on the task, you must determine the amount of the ability which is required. To do this proceed to the right-hand page.

Fourth, on the right hand page you will find a seven-point scale relating to the ability defined on the left-hand page. General definitions of the high and low levels of the ability are presented to the left of the scale while to the right are examples of tasks which display different amounts of the ability. The definitions present the critical factors which determine the amount of the ability required. In other words, more than one aspect of the task may determine the amount of the ability which is required.

Take for example an ability which is affected by two aspects of the task. A scale rating of medium could be achieved by the ability being medium on both of the underlying dimensions or by being high on one and low on the other. It should be noted that not all of the abilities vary over multiple dimensions.

The examples which are placed along the right-hand side of the scale serve as concrete anchors for the scale. They are there to provide you with reference points for rating the task you are considering. They should be employed by asking the question "Does the task which I am considering require more or less of the ability than this example?"

In rating the task, you are attempting to estimate the lowest amount of the ability a subject could possess and still produce errorless performance on the task. Two points are important here. First, it is possible that if X amount of the ability will yield errorless performance, an amount greater than X will also yield errorless performance. Therefore, keep in mind that you are asked to estimate X or the lowest amount which will still produce errorless performance. The second point is that you are considering the amount of the ability required for performance and not that required for the learning of the task. You must assume that the subject has already learned the task and that he is now performing it at an errorless level.

Once you have reached a conclusion as to the amount of the ability required by the task you are rating, mark your answer by placing an "X" on the rating scale on the answer sheet. Please remember to use the scale on the answer sheet and not the one in the reference manual.

Five, continue the procedures outlined above until you have rated the task with respect to all thirty-seven abilities presented in the reference manual.

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AIR-726-EX

TASK ASSESSMENT SCALES
REFERENCE MANUAL

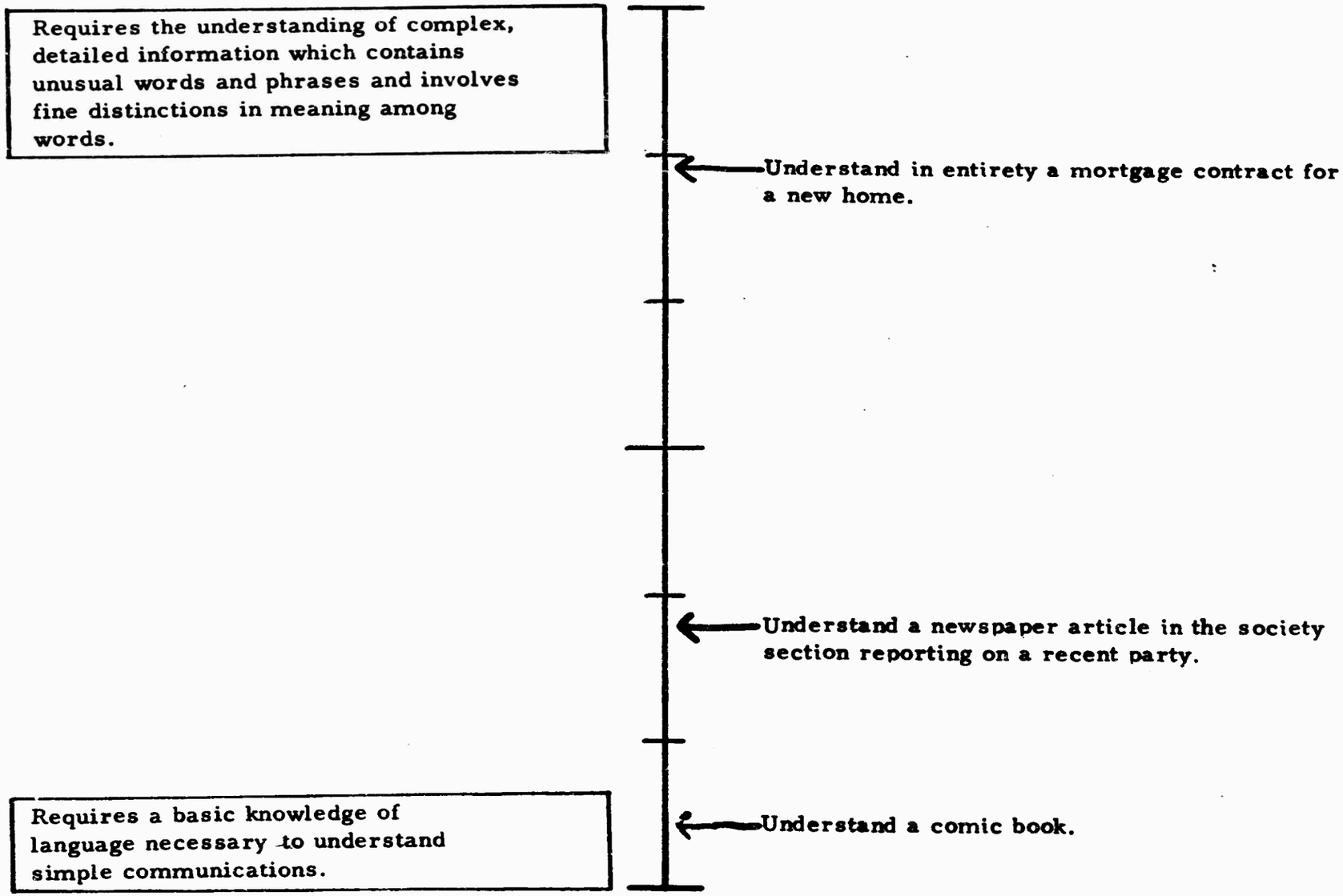
1. VERBAL COMPREHENSION

This is the ability to understand language. It is concerned with the understanding of individual words as well as words as they appear in context; i.e., in sentences, grammatical patterns and idiomatic phrases. In terms of communication, this ability is limited to the receiver of information; it does not apply to the sender or communicator.

VERBAL COMPREHENSION DISTINGUISHED FROM OTHER ABILITIES:

Understanding individual words and words in context.	vs.	Ideational Fluency (3): Production of ideas relevant to a topic.
Characteristic of receiver of information.	vs.	Verbal Expression (2): Characteristic of sender of information.

1. VERBAL COMPREHENSION



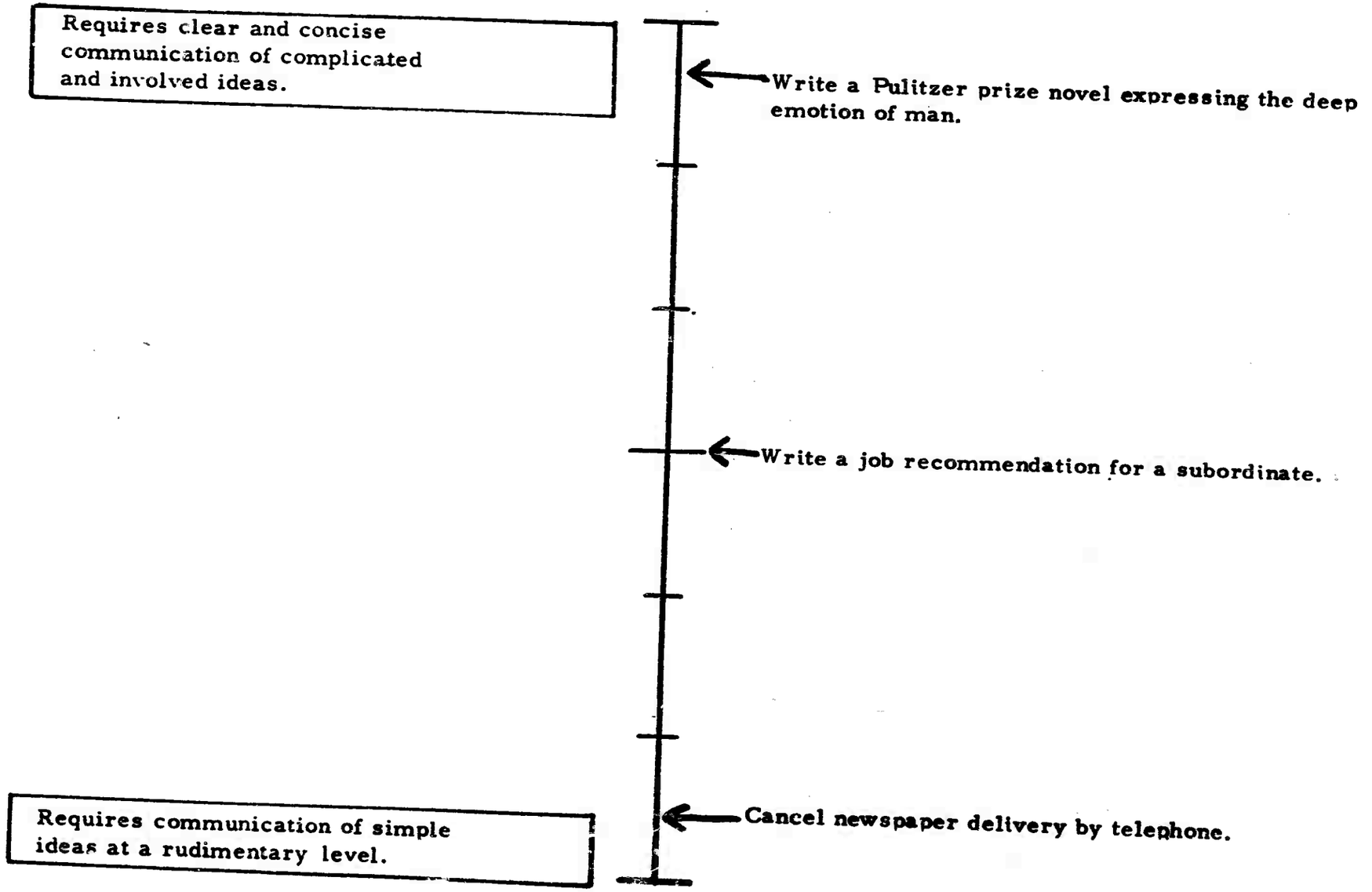
2. VERBAL EXPRESSION

This is the ability to utilize language (either oral or written) to communicate information or ideas to another person or persons. It requires the production and utilization of individual words or of words in context (i.e., in phrases, sentences, etc.) to express ideas or factual information. Neither the actual production of the ideas nor questions relating to the quality of an idea are included under this ability. The ability is concerned solely with the quality of the communication of such ideas. Quality of communication can be thought of as depending upon factors such as (1) size of one's vocabulary, (2) knowledge of distinctions among words and (3) knowledge of grammar and syntax.

VERBAL EXPRESSION DISTINGUISHED FROM OTHER ABILITIES:

<table>
<tr><td>Characteristic of the sender information.</td><td>vs.</td><td>Verbal Comprehension (1): Characteristics of the receiver of information.</td></tr>
<tr><td rowspan="2">Quality of the communication of ideas.</td><td rowspan="2">vs.</td><td>Ideational Fluency (3): Quantity of ideas produced.</td></tr>
<tr><td>Originality (4): Quality of ideas produced.</td></tr>
</table>

2. VERBAL EXPRESSION



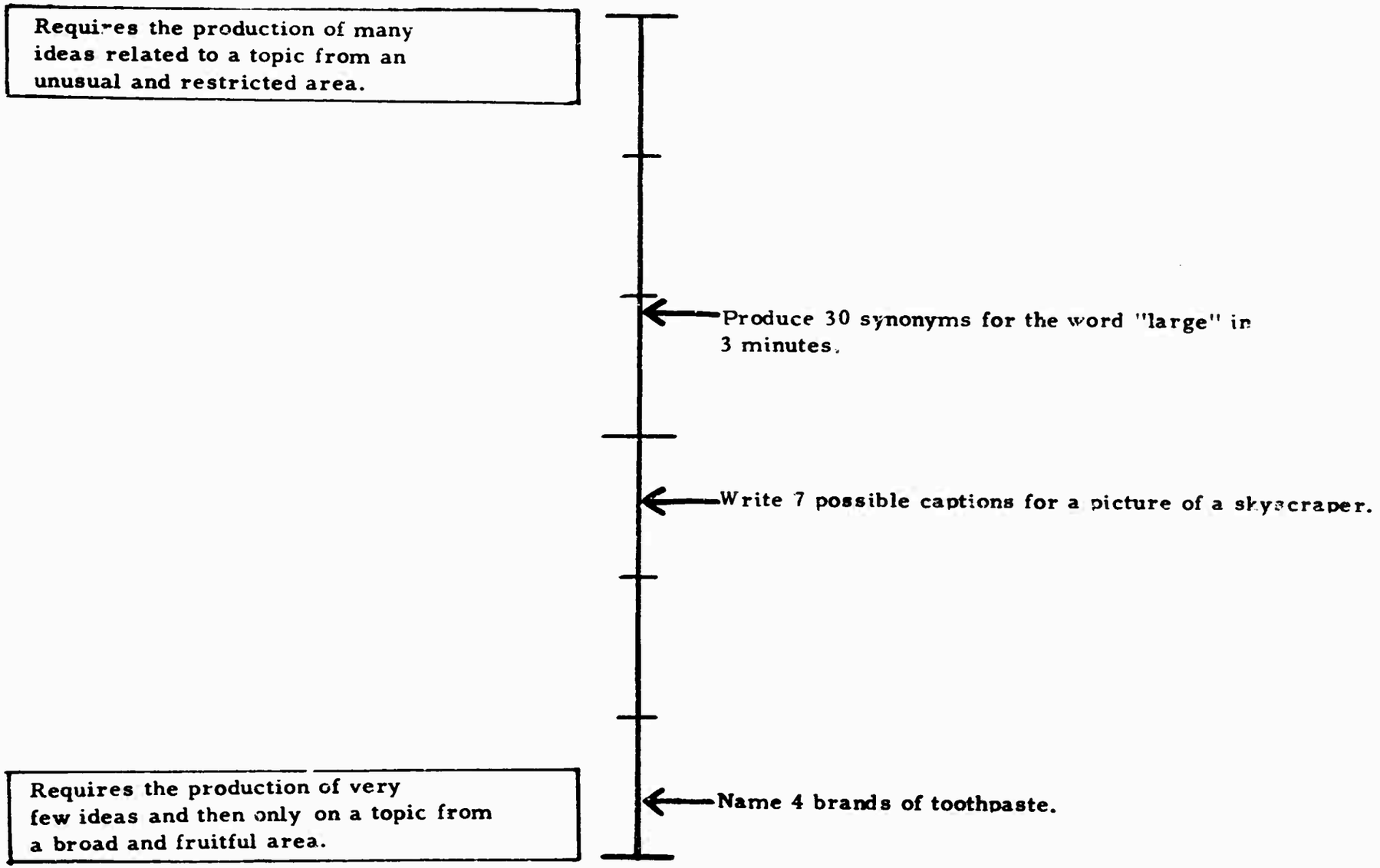
3. IDEATIONAL FLUENCY

This is the ability to produce a number of ideas concerning a given topic. It is only concerned with the number of ideas produced and does not extend to the quality of those ideas.

IDEATIONAL FLUENCY DISTINGUISHED FROM OTHER ABILITIES:

<table>
<tr><td>Deals with sheer number of responses; i.e., quantity.</td><td>vs.</td><td>Originality (4): Concerns the creativity of responses; i.e., quality.</td></tr>
<tr><td rowspan="2">Production of ideas.</td><td rowspan="2"></td><td>Verbal Comprehension (1) : Understanding of individual words and of words in context.</td></tr>
<tr><td>vs.</td><td>Verbal Expression (2): Communication of ideas.</td></tr>
</table>

3. IDEATIONAL FLUENCY



4. ORIGINALITY

This is the ability to produce unusual or clever responses related to a given topic or situation. It is the ability to improvise solutions to problems or to develop procedures in situations where standard operating procedures do not apply. This ability is concerned with the degree of creativity of responses and does not deal with the number of responses made.

ORIGINALITY DISTINGUISHED FROM OTHER ABILITIES:

Concerns the creativity of the response; i.e., quality.	vs.	Ideational Fluency (3): Deals with the sheer number of responses; i.e., quantity.
Quality of the ideas.	vs.	Verbal Expression (2): Quality of the communication of ideas.

4. ORIGINALITY

Requires the production of extremely clever or creative responses related to an unusual or novel topic or situation.

Research chemist invents a new synthetic fiber.

Design a bookcase using only bricks and boards so that is both attractive and functional.

Requires the production of responses which show very little creativity; such responses would not be much better than repetitions of "classic" responses.

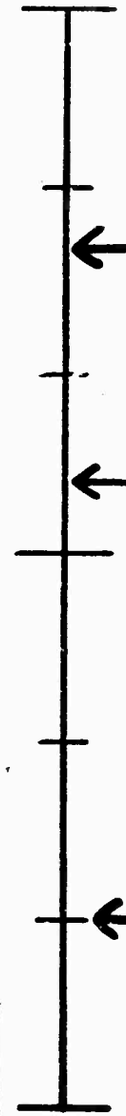
Auto mechanic adjusts the carburetor idle by using a dime in absence of a screw driver, after his co-worker suggested it.

5. MEMORIZATION

This is the ability to memorize and retain new information which occurs as a regular or routine part of the task. These new bits of information must be memorized to properly accomplish or carry out the task. This ability does not extend either to the memorization of the task procedures or to the recall of any information previously learned outside of the given task situation.

5. MEMORIZATION

Requires the memorization and recall of a large amount of ordered material where the associational value of the items is low; that is, the recall of a given item is not aided by association with other items in the series or by association with material external to the series.



After examining 21 pictures of common objects, each paired with a 2 digit number for 4 minutes, write the appropriate number under each picture when they are presented in a different order.

Memorize the names and locations of all the African countries so that when an outline map is presented, the countries can be correctly labeled.

Memorize a 3 digit combination for a gym locker, including both the numbers and direction.

Requires the memorization and recall of a small amount of information where there is high associational value among the items. These items may be recalled in any order.

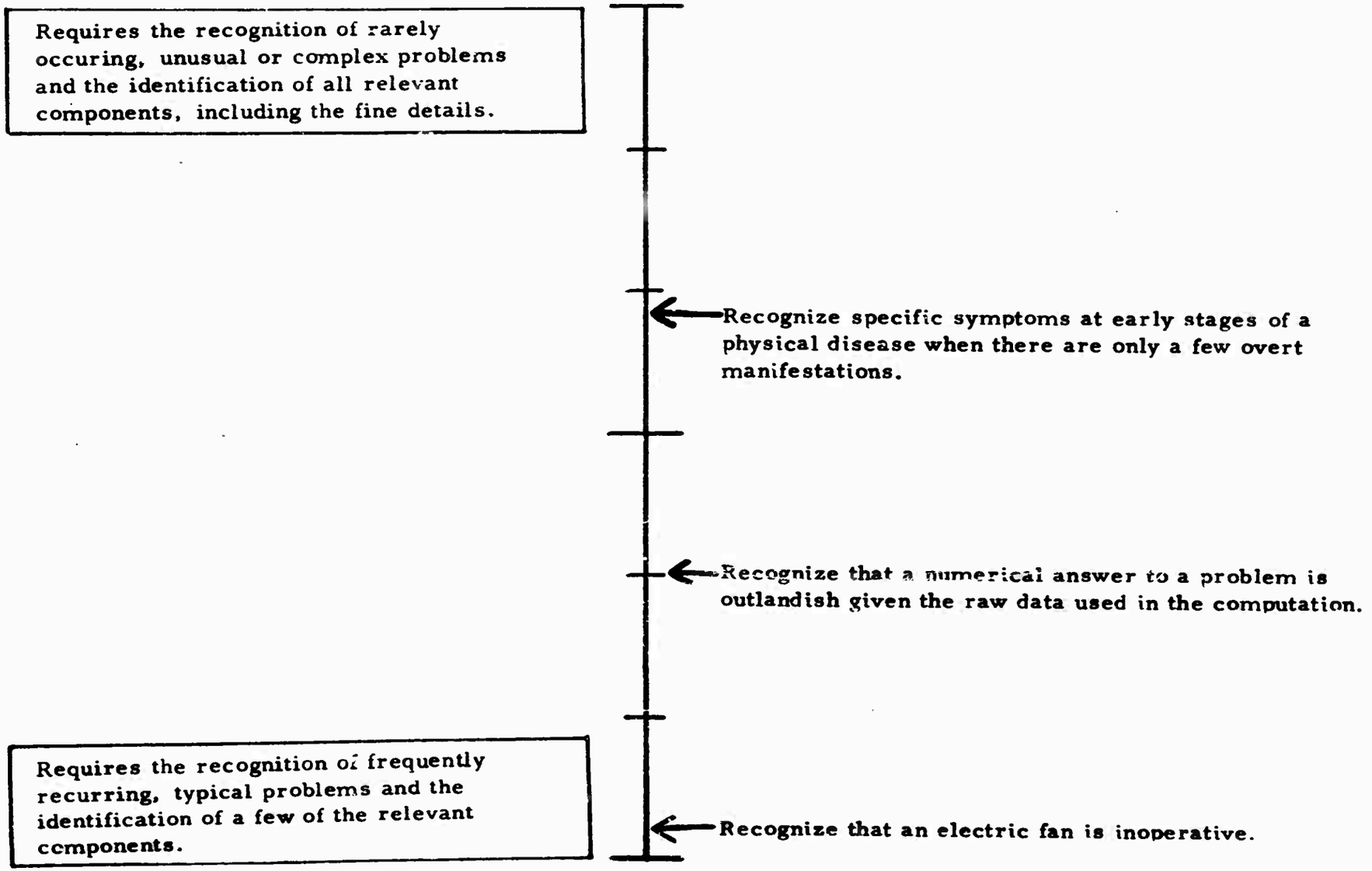
6. PROBLEM SENSITIVITY

This is the ability to recognize or identify the existence of problems. It includes the specification of the problem as a whole as well as recognition of the elements of the problem. This ability encompasses all types of problems whether they be figural, symbolic or semantic. However, the ability does not include any of the reasoning necessary for the solution of a problem.

PROBLEM SENSITIVITY DISTINGUISHED FROM OTHER ABILITIES:

Recognition and identification of problems.	vs.	Mathematical Reasoning (7), Deductive Reasoning (9) and Inductive Reasoning (10): Reasoning to the solution of problems.

6. PROBLEM SENSITIVITY



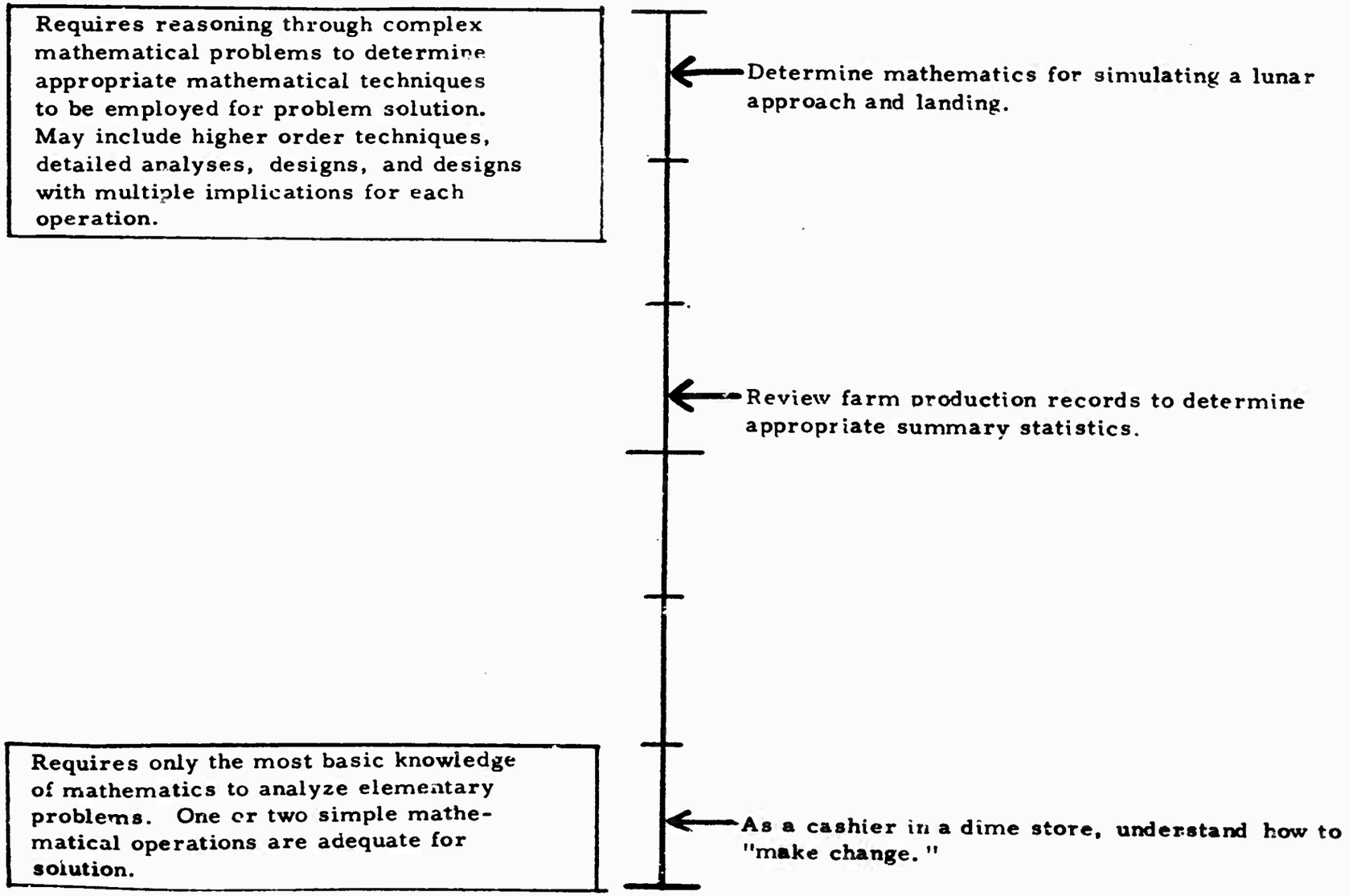
7. MATHEMATICAL REASONING

This is the ability to reason abstractly using quantitative concepts and symbols. It encompasses reasoning through mathematical problems in order to determine appropriate operations which can be performed to solve them. It also includes the understanding or structuring of mathematical problems. The actual manipulation of numbers is not included in this ability.

MATHEMATICAL REASONING DISTINGUISHED FROM OTHER ABILITIES:

Deals with mathematical problems only.	vs.	Deductive Reasoning (9) and Inductive Reasoning (10): Deal with non-mathematical problems.
Deals with understanding or structuring of mathematical problems.	vs.	Number Facility (8): Deals with the manipulation of numbers in mathematical problems.

7. MATHEMATICAL REASONING



8. NUMBER FACILITY

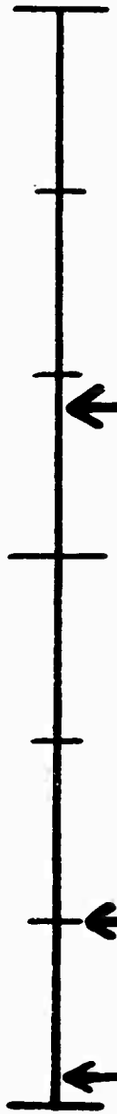
This is the ability to manipulate numbers in numerical operations: for example, add, subtract, multiply, divide, integrate, differentiate, etc. The ability involves both the speed and accuracy of computation.

NUMBER FACILITY DISTINGUISHED FROM OTHER ABILITIES:

Deals with the manipulation of numbers in mathematical problems.	vs.	Mathematical Reasoning (7): Deals with understanding or structuring of mathematical problems.

8. NUMBER FACILITY

Requires the rapid manipulation of numbers in highly complex mathematical operations.



Compute the volume of coal ore in portions of a mine using survey notes.

Check accuracy of restaurant bill against the prices listed in the menu and then recompute the bill.

Add 2 and 7.

Requires the manipulation of numbers using simple numerical operations or techniques when more than enough time is available.

9. DEDUCTIVE REASONING

This is the ability to apply general concepts or rules to specific cases or to proceed from stated premises to their logical conclusions. This ability can also be termed syllogistic reasoning or analytic reasoning in that progression is from the whole to the parts.

DEDUCTIVE REASONING DISTINGUISHED FROM OTHER ABILITIES:

Reasoning from the general to the specific.	vs.	Inductive Reasoning (10): Reasoning from the specific to the general.
Deals with non-mathematical problems.	vs.	Mathematical Reasoning (7): Deals with mathematical problems only.

9. DEDUCTIVE REASONING

Requires detailed reasoning about highly abstract and intricate problems, involving many logical steps and operations to arrive at conclusions. The relationships between the premises and conclusions are rather vague.

← Design an aircraft wing using the principles of aerodynamics.

← What factors would you take into account in planning your vaction to Mexico.

Requires only a very low level of reasoning about simple, concrete problems involving only one or a few logical steps to reach conclusions. The relationships between the premises and conclusions are rather obvious.

← Decide whether or not to take an umbrella.

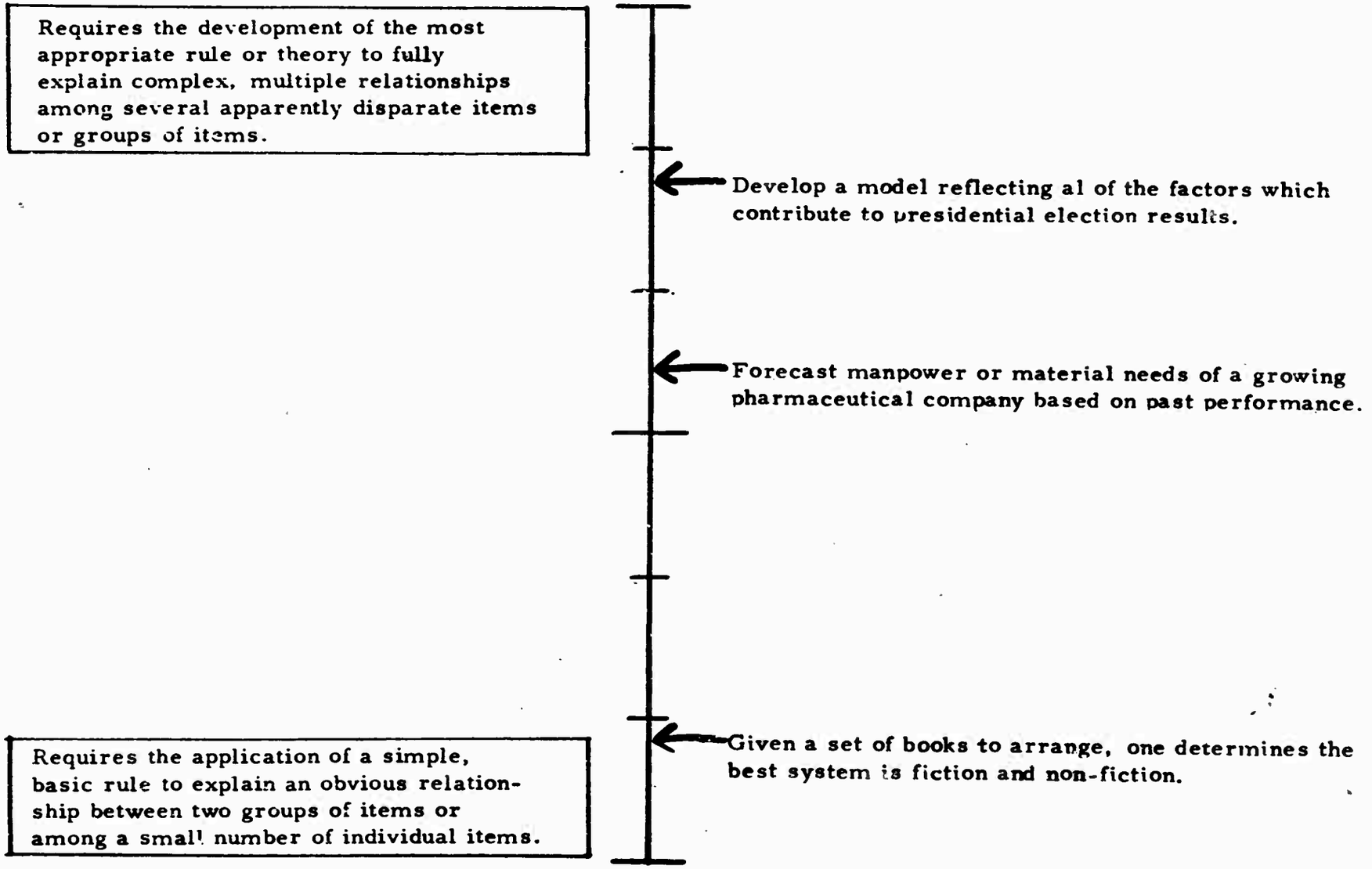
10. INDUCTIVE REASONING

This is the ability to find the most appropriate general concepts or rules which fit sets of data or which explain how a given series of individual items are related to each other. It involves the ability to synthesize disparate facts; to logically proceed from individual cases to general principles. It also involves the ability to form hypotheses about relationships among items or data.

INDUCTIVE REASONING DISTINGUISHED FROM OTHER ABILITIES:

Reasoning from the specific to the general.	vs.	Deductive Reasoning (9): Reasoning from the general to the specific.
Deals with non-mathematical problems.	vs.	Mathematical Reasoning (7): Deals with mathematical problems only.
Discovery of best or most appropriate rules for explanation of given information.	vs.	Information Ordering (11): Application of previously specified rules or objectives to given information.
		Category Flexibility (12): Production of many rules which could be applied to given information.

10. INDUCTIVE REASONING



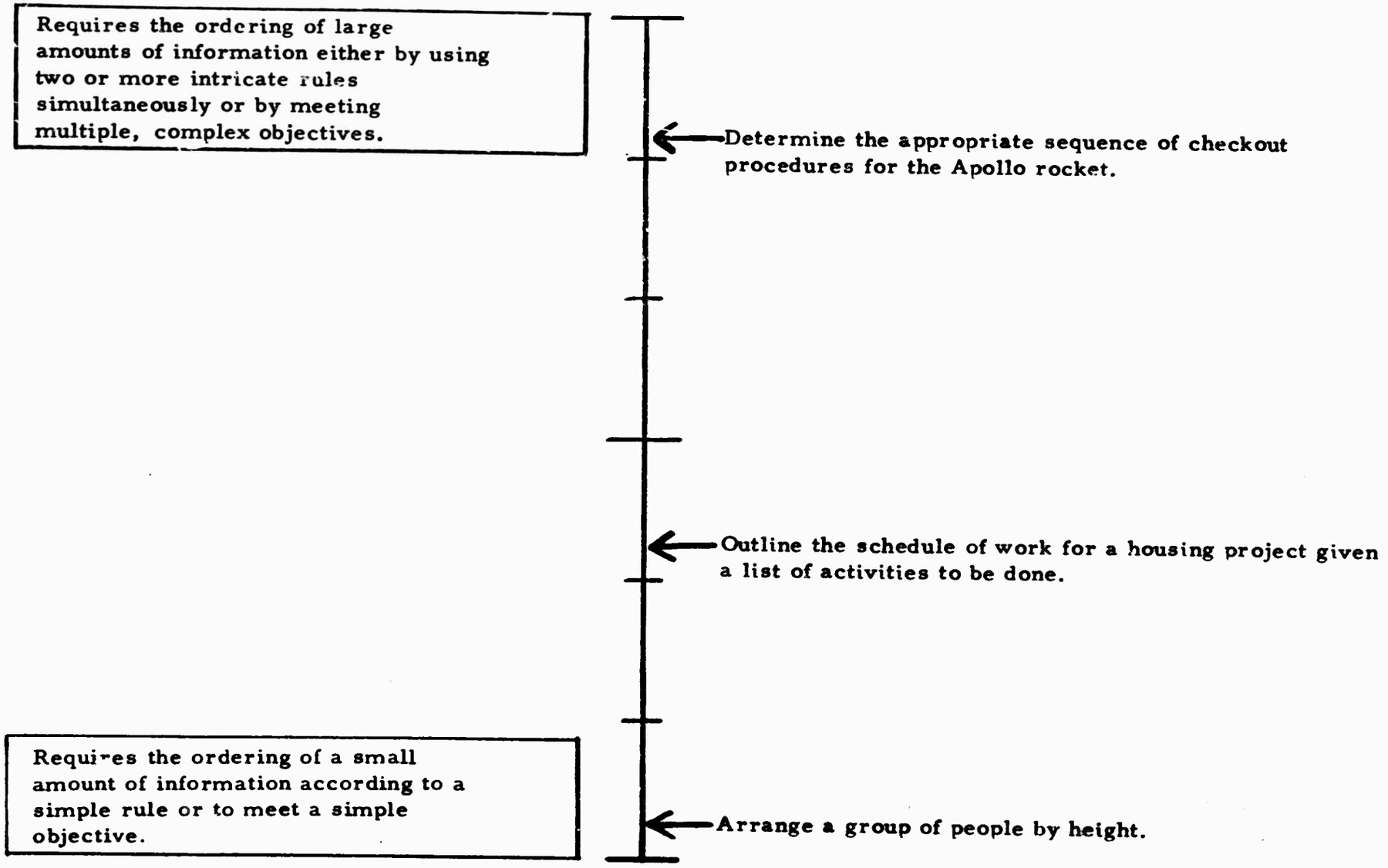
11. INFORMATION ORDERING

This is the ability to apply rules or objectives to given information in order to arrange that information into the best or most appropriate sequence. The types of information considered under this ability includes numbers, letters, words, pictures, procedures, sentences, and mathematical or logical operations. Rules or objectives for ordering must first be provided to the operator or subject in the task.

INFORMATION ORDERING DISTINGUISHED FROM OTHER ABILITIES:

Application of previously specified rules or objectives to given information.	vs.	Category Flexibility (12): Production of many rules which could be applied to given information.
		Inductive Reasoning (10): Discovery of the best or most appropriate rules for explanation of given information.

11. INFORMATION ORDERING



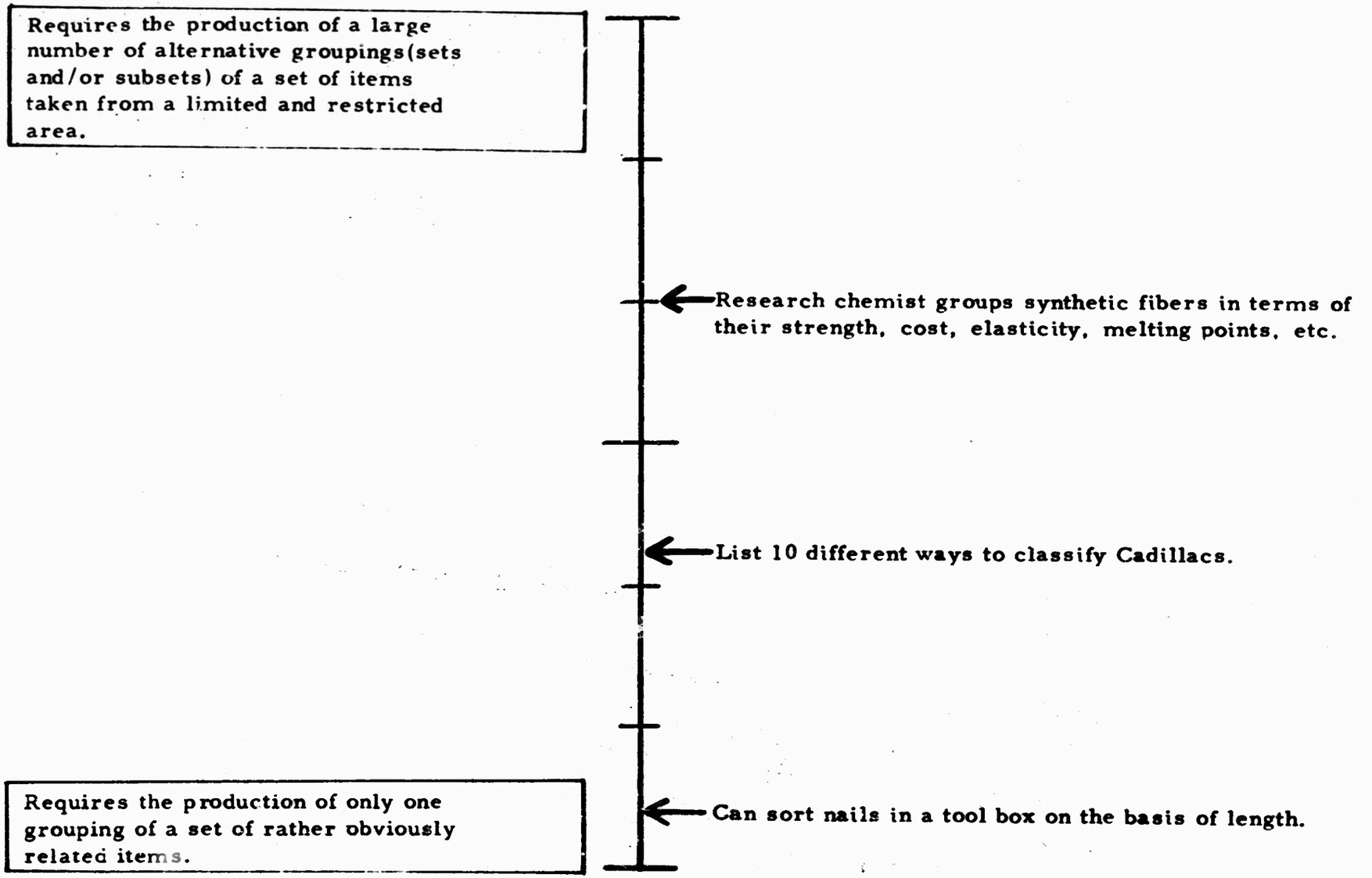
12. CATEGORY FLEXIBILITY

This is the ability to produce alternative groupings or categorizations for a set of items, based upon rules or specifications produced by the individual who is carrying out the categorization. Each alternative group must contain at least two items from the initial list, but any specific set of alternative groups need not contain all of the items from the initial list.

CATEGORY FLEXIBILITY DISTINGUISHED FROM OTHER ABILITIES:

Production of many rules which could be applied to given information.	vs.	Information Ordering (11): Application of previously specified rules or objectives to be given information.
		Inductive Reasoning (10): Discovery of the best or most appropriate rules for explanation of given information.

12. CATEGORY FLEXIBILITY



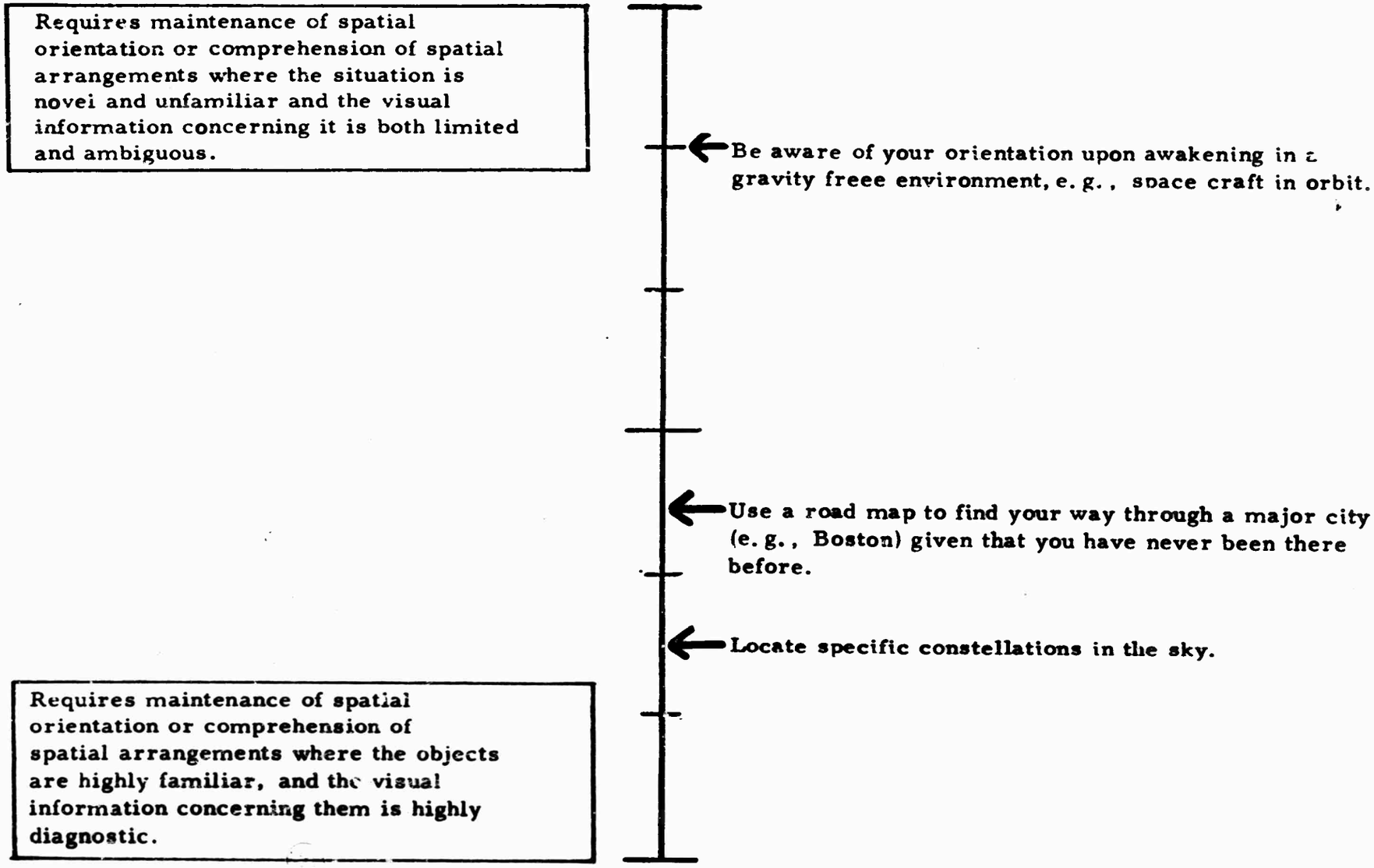
13. SPATIAL ORIENTATION

This is the ability to maintain one's orientation with respect to objects in space or to comprehend the position of objects in space with respect to the observer's position. The question posed is often "If the environment looks like this, what is my position?"

SPATIAL ORIENTATION DISTINGUISHED FROM OTHER ABILITIES:

Comprehension of the arrangement of spatial patterns or maintenance of orientation with respect to objects in space.	vs.	Visualization (14): Manipulation or transformation of the image of spatial patterns or objects into other spatial arrangements.

13. SPATIAL ORIENTATION



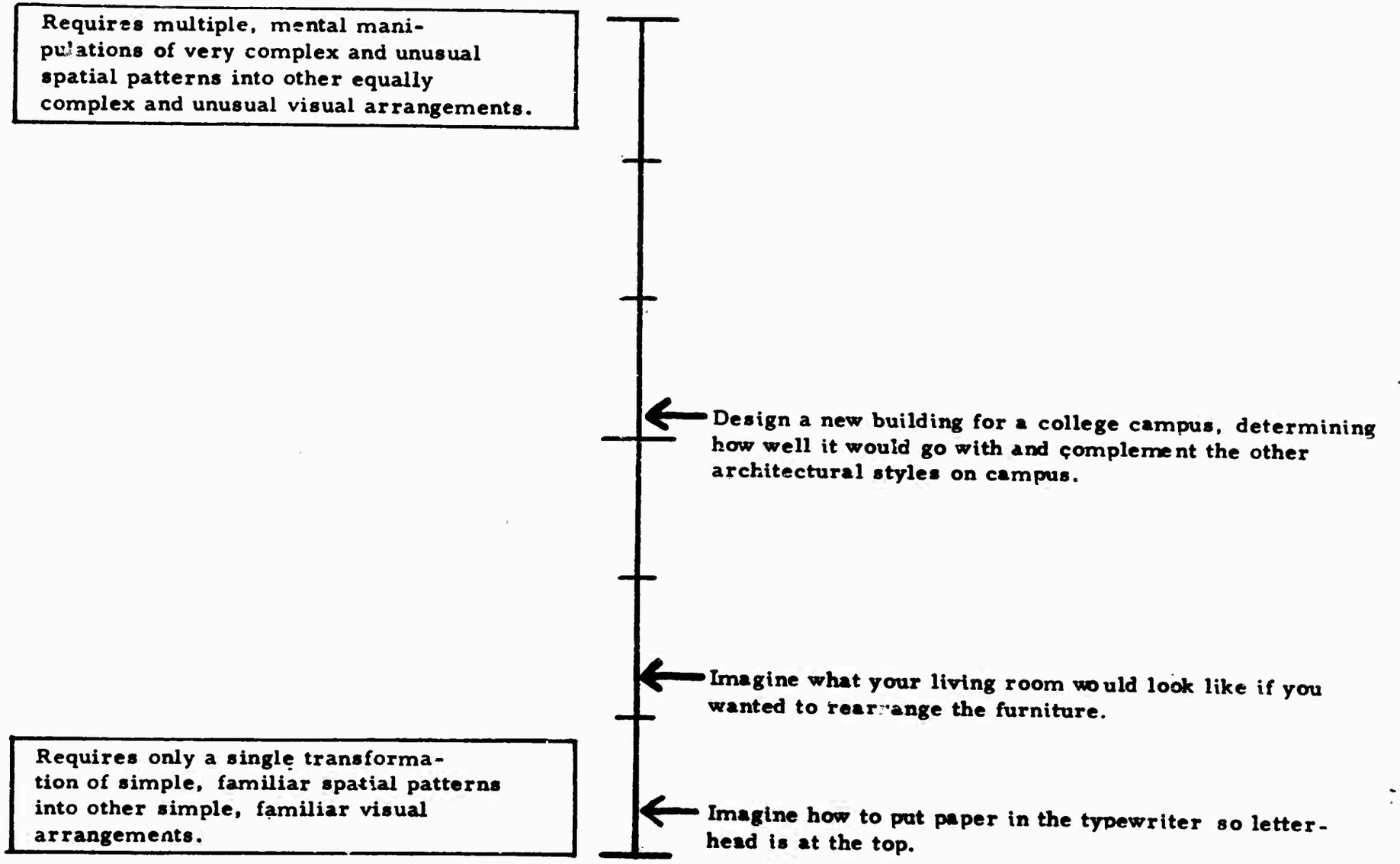
14. VISUALIZATION

This is the ability to manipulate or transform the visual images of spatial patterns or objects into other spatial arrangements. It requires the formation of mental images of the patterns or objects as they would appear after certain specified changes such as unfolding, rotation, or movement of some type. The transformation or set of transformations the observer is asked to make may involve either entire spatial patterns or objects or parts of those patterns or objects. The observer predicts what an object, set of objects or pattern would look like after the specified changes were actually carried out.

VISUALIZATION DISTINGUISHED FROM OTHER ABILITIES:

Manipulation or transformation of the image of spatial patterns or objects into other spatial arrangements.	vs.	Spatial Orientation (13): Comprehension of the arrangement spatial patterns or maintenance of orientation with respect to objects in space.

14. VISUALIZATION



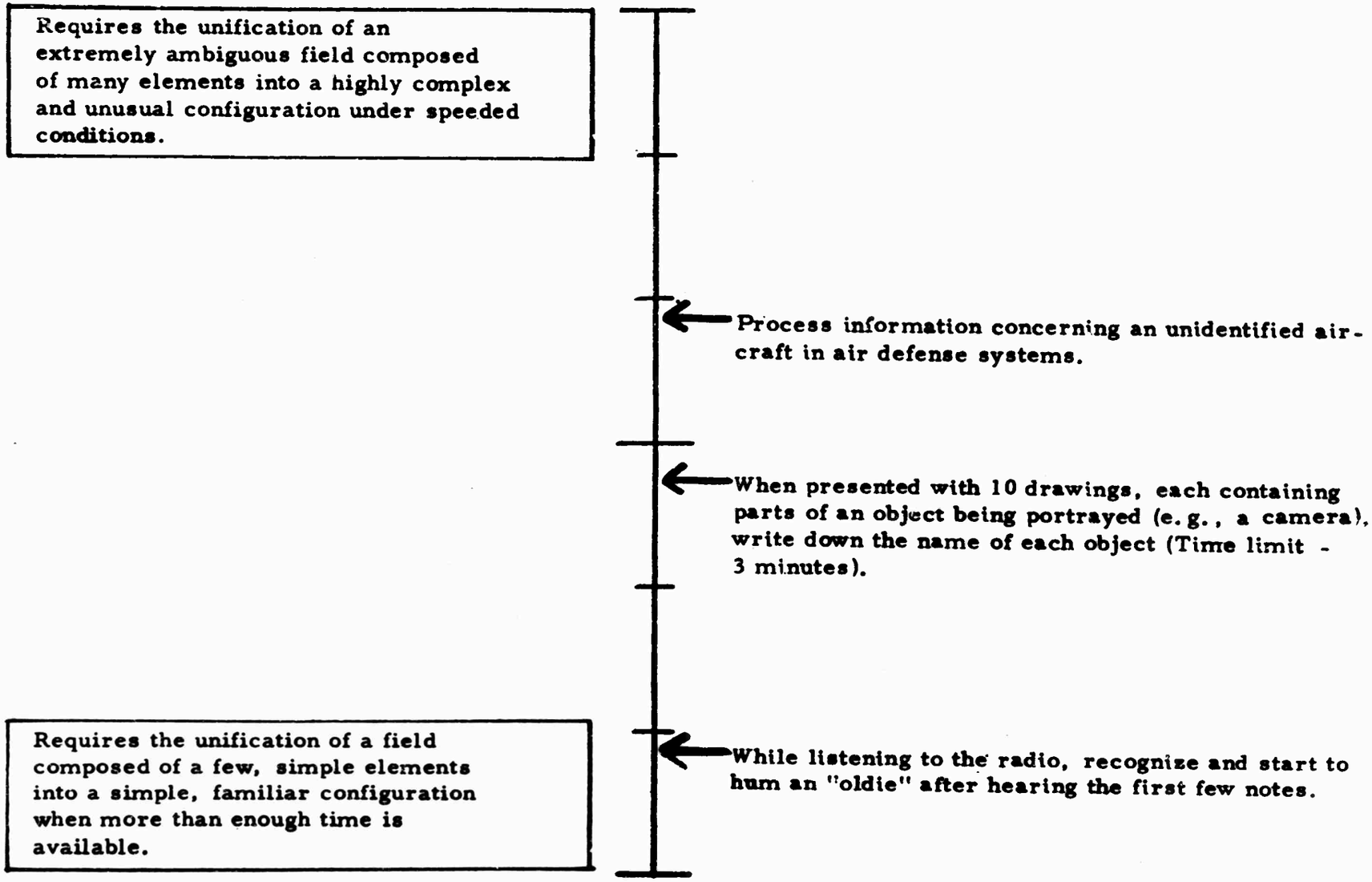
15. SPEED OF CLOSURE

This ability involves the speed with which a set of apparently disparate sensory elements can be combined and organized into a single, meaningful pattern or configuration. The operator must combine all the elements presented from a single source of information into a meaningful configuration. He is not told what he is trying to identify; the elements appear to be disparate. This ability applies to all senses with the restriction that elements to be combined must be presented within the same sensory modality.

SPEED OF CLOSURE DISTINGUISHED FROM OTHER ABILITIES:

Operator is not told what he is trying to identify.	vs.	Flexibility of Closure (16): Operator tries to identify a specified configuration embedded in a more complex sensory field.
All of the stimuli presented are relevant to the task.	vs.	Selective attention (17): Some of the stimuli are not relevant to the task.
Only one source of information is involved.	vs.	Time Sharing (18): More than one source of information is utilized.

15. SPEED OF CLOSURE



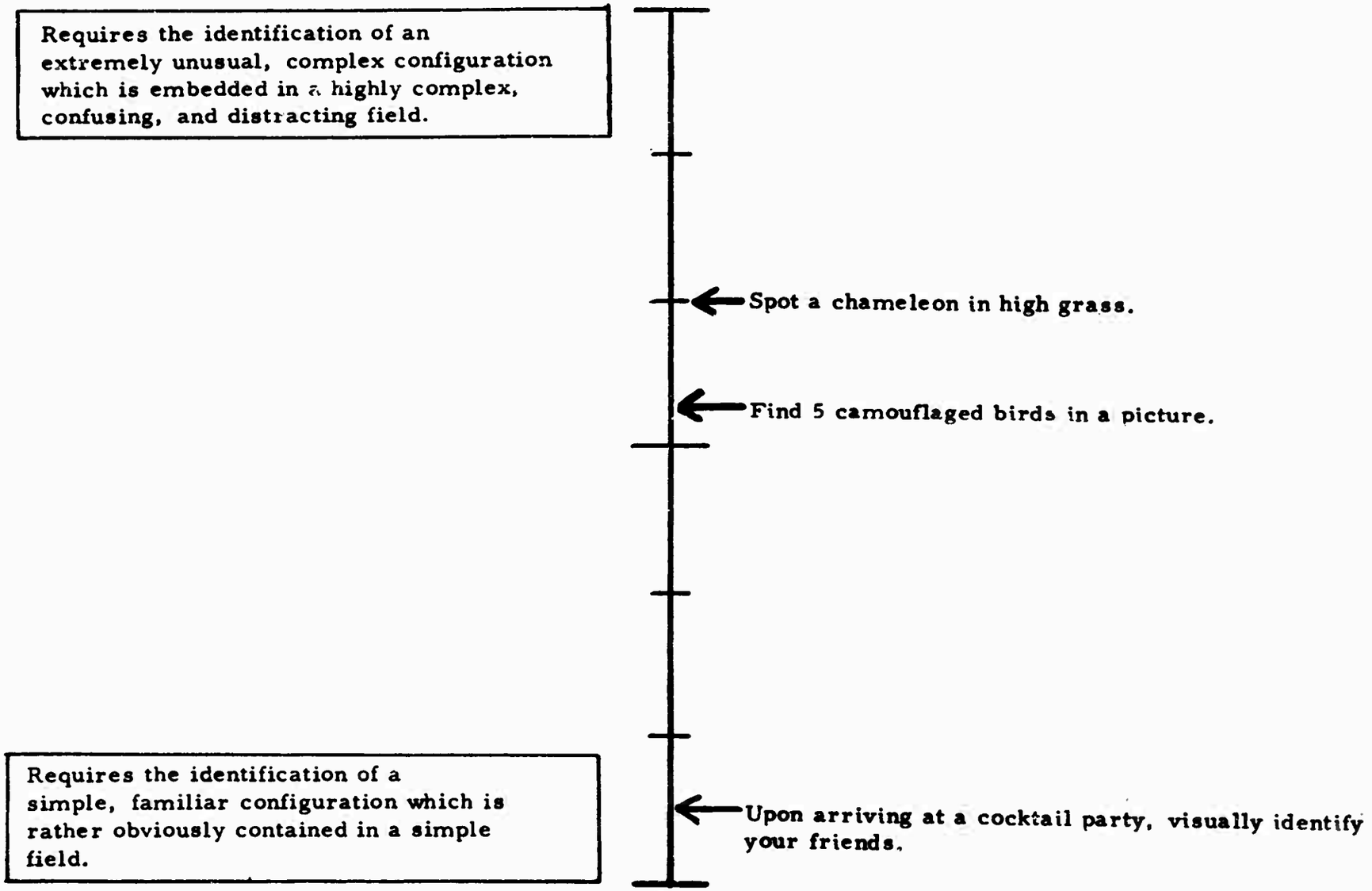
16. FLEXIBILITY OF CLOSURE

This is the ability to identify or detect a previously specified stimulus configuration which is embedded in a more complex sensory field. It is the ability to isolate the specified relevant stimulus from a field where distracting stimulation is intentionally included as part of the task to be performed. Only one information source is utilized. This ability applies to all senses with the restriction that both the relevant and distracting stimulation must occur within the same sense modality.

FLEXIBILITY OF CLOSURE DISTINGUISHED FROM OTHER ABILITIES:

Operator tries to identify a specified configuration.	vs.	Speed of Closure (15): Operator is not told what he is trying to identify.
Distracting stimulation is included in the task to be performed; i.e., it is an integral part of the task.	vs.	Attention (17): Distracting stimulation is not included in the task to be performed; i.e., it is external to the task.
Only one source of information is utilized.	vs.	Time Sharing (18): More than one source of information is utilized.

1o. FLEXIBILITY OF CLOSURE



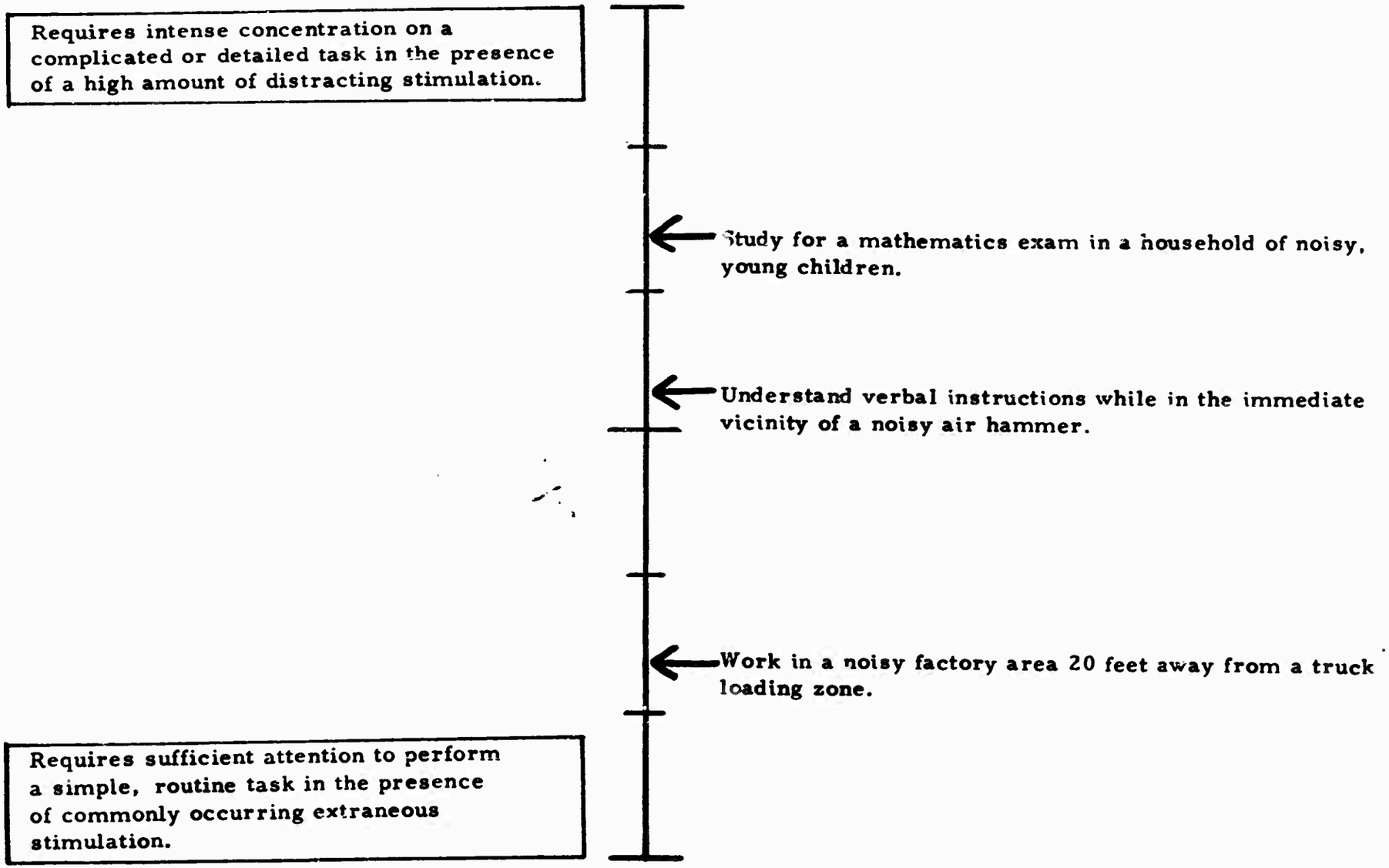
17. SELECTIVE ATTENTION

This is the ability to perform a task in the presence of distracting stimulation or under monotonous conditions without significant loss in efficiency. When distracting stimulation is present in the task situation, it is not an integral part of the task being performed, but rather is extraneous to the task and imposed upon it. The task and the irrelevant stimulation can occur either within the same sense or across senses. Under conditions of distracting stimulation, the ability involves concentration on the task being performed and filtering out of the distracting stimulation. When the task is performed under monotonous conditions only concentration on the task being performed is involved.

SELECTIVE ATTENTION DISTINGUISHED FROM OTHER ABILITIES:

Some of the stimuli are not relevant to the task.	vs.	Speed of Closure (15): All of the stimuli are relevant to the task.
Distracting stimulation is not included in the task to be performed; i.e., it is external to the task.	vs.	Flexibility of Closure (16): Distracting stimulation is included in the task to be performed, it is an integral part of the task.
Concentration on relevant information and filtering out distracting stimulation.	vs.	Time Sharing (18): Involves utilization or integration of information obtained from two or more sources.

17. SELECTIVE ATTENTION



18. TIME SHARING

This is the ability to utilize information obtained by shifting between two or more channels of information. The information obtained from these sources is either integrated and used as a whole or retained and used separately.

TIME SHARING DISTINGUISHED FROM OTHER ABILITIES:

More than one source of information is utilized.	vs.	Speed of Closure (15) and Flexibility of Closure (16); Only one source of information is utilized.
Utilization or integration of information from more than one source.	vs.	Selective Attention (17): Concentration on relevant information and filtering out of distracting stimulation.

18. TIME SHARING

Requires the simultaneous use of two or more channels of complex information where the rate of information input in each channel is rapid.

Air traffic controller monitors radar scope to keep track of inbound and outbound planes during a period of heavy, congested traffic.

Playground director supervises 50 children who are engaging in many different activities.

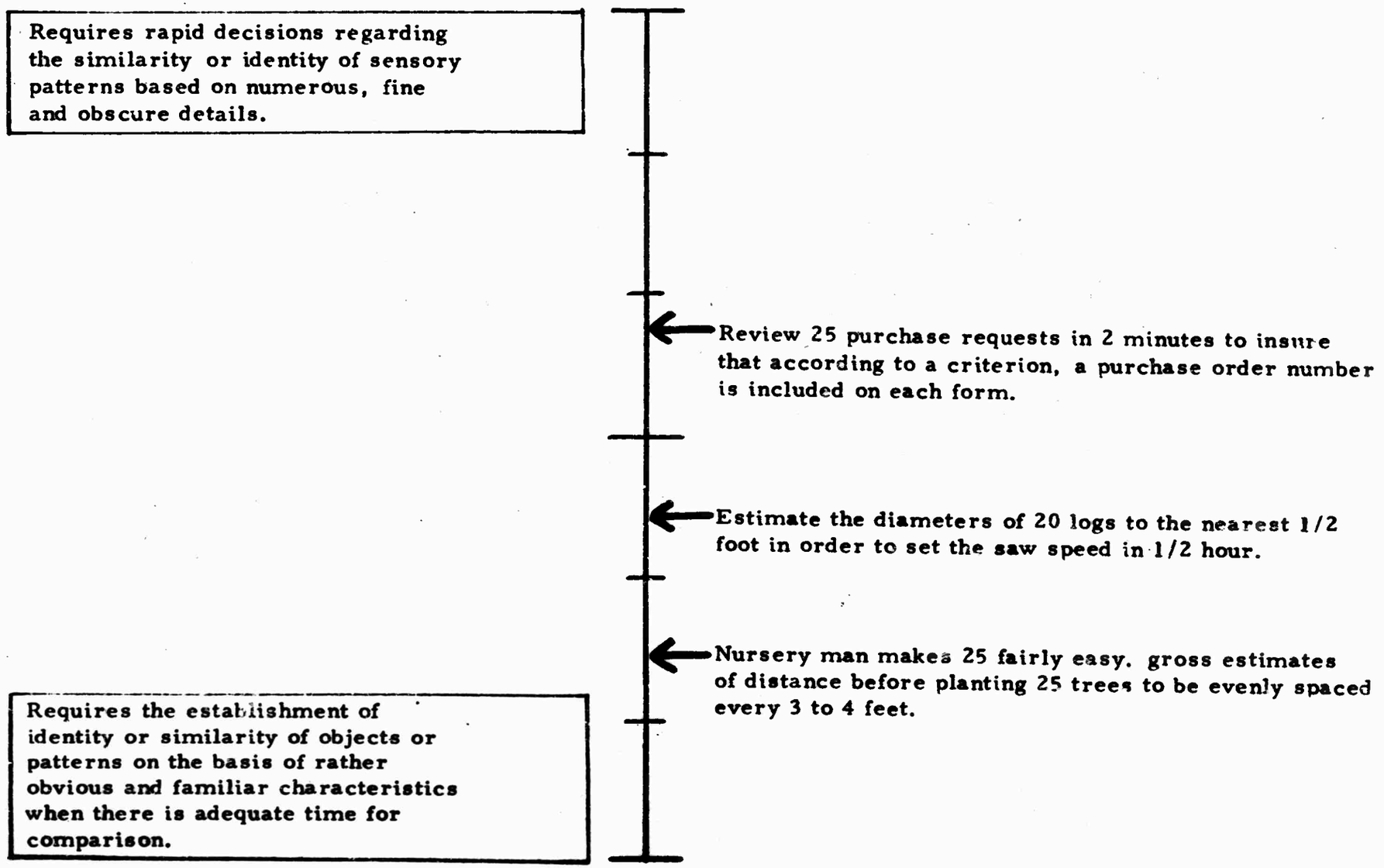
Short stop watches the lead of the runner on second and actions of the pitcher.

Requires the utilization of two channels of rather simple information where the operator can shift sequentially between channels in which the rate of information input is low.

19. PERCEPTUAL SPEED

This ability involves the speed with which sensory patterns or configurations can be compared in order to determine identity or degree of similarity. Comparisons may be made either between successively or simultaneously presented patterns or configurations, or between remembered or standard configurations and presented configurations. The sensory patterns to be compared must occur within the same sense and not between senses.

19. PERCEPTUAL SPEED



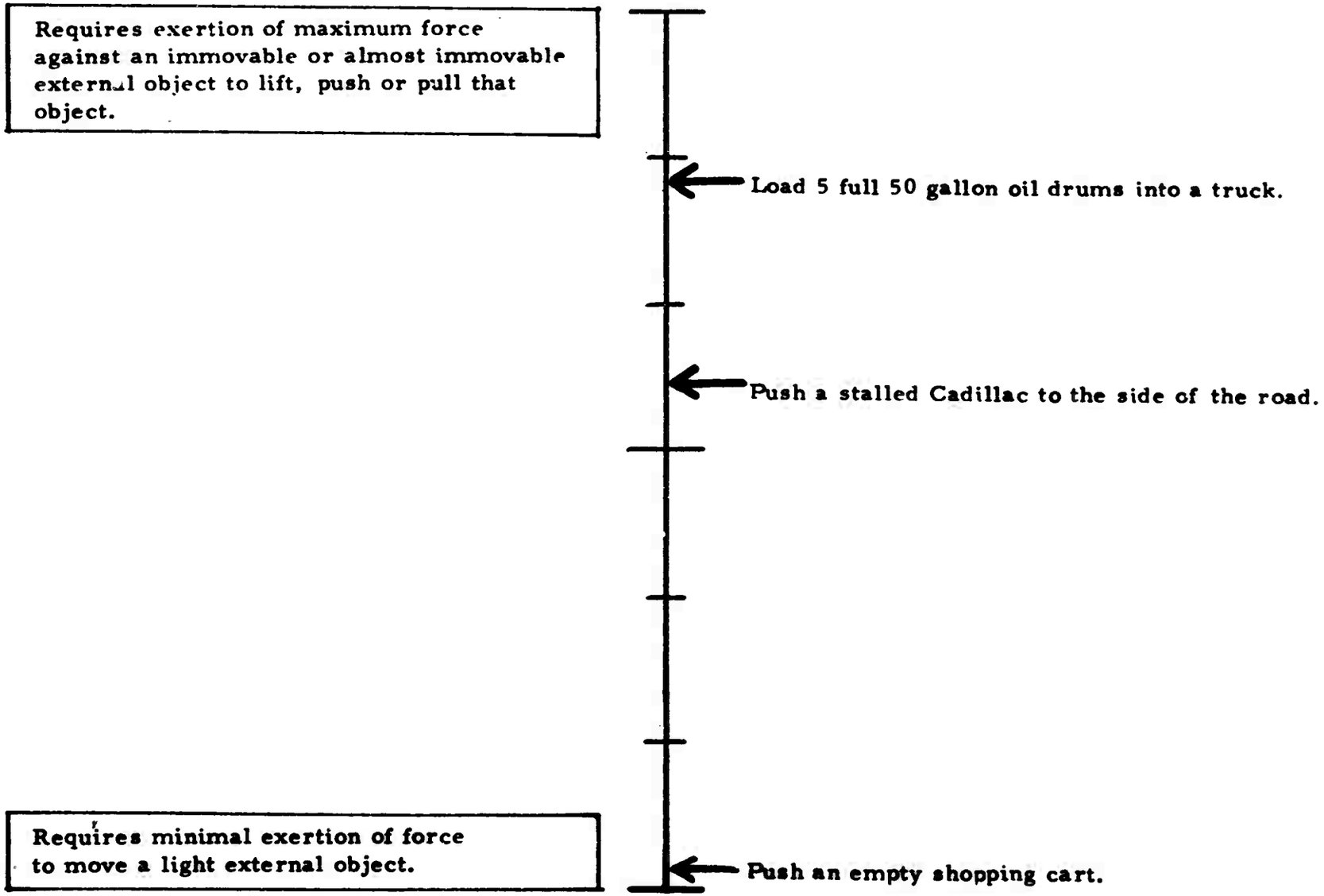
20. STATIC STRENGTH

This ability involves the degree of muscular force exerted against fairly immovable or heavy external object in order to lift, push, or pull that object. Force is exerted continuously up to the amount needed to move the object. This ability is general to different muscle groups (e.g., hand, arm, back, shoulder, leg). This ability does not extend to prolonged exertion of physical force over time and is not concerned with the number of times the act is repeated.

STATIC STRENGTH DISTINGUISHED FROM OTHER ABILITIES:

Exertion of continuous force to lift, push, or pull external objects.	vs.	Explosive Strength (21): Mobilization of energy to propel body's weight or external objects in bursts of effort.
Exertion of force to lift, push, or pull external objects.	vs.	Dynamic Strength (22): Exertion of muscular force to repeatedly or continuously support the body's own weight.
Does not involve prolonged exertion of force over time.	vs.	Stamina (23): Involves prolonged physical activity; involves cardiovascular resistance to fatigue.

20. STATIC STRENGTH



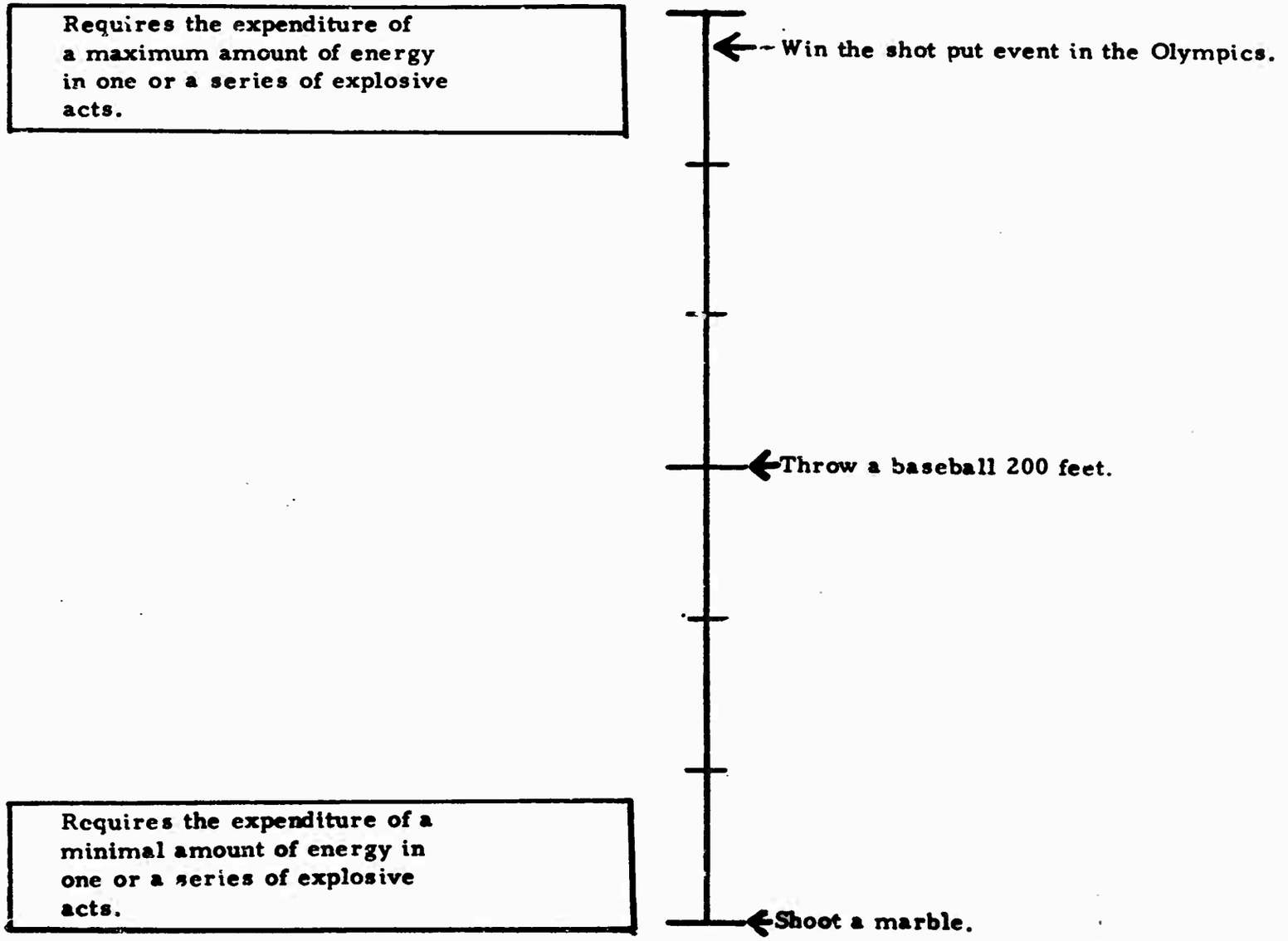
21. EXPLOSIVE STRENGTH

This is the ability to expend energy in one or a series of explosive muscular acts. The ability requires a mobilization of energy for a burst of muscular effort, rather than continuous strain, stress, or repeated exertion of muscles. The ability may be involved in propelling the body as in jumping or sprinting or in throwing objects for distance.

EXPLOSIVE STRENGTH DISTINGUISHED FROM OTHER ABILITIES:

Bursts of energy to propel body or objects.	vs.	Static Strength (20): Exertion of continuous force to lift, push or pull external objects.
		Dynamic Strength (22): Continuous or repeated strain or stress on muscles in supporting body.
		Stamina (23): Involves prolonged physical activity; involves cardio-vascular resistance to fatigue.

21. EXPLOSIVE STRENGTH



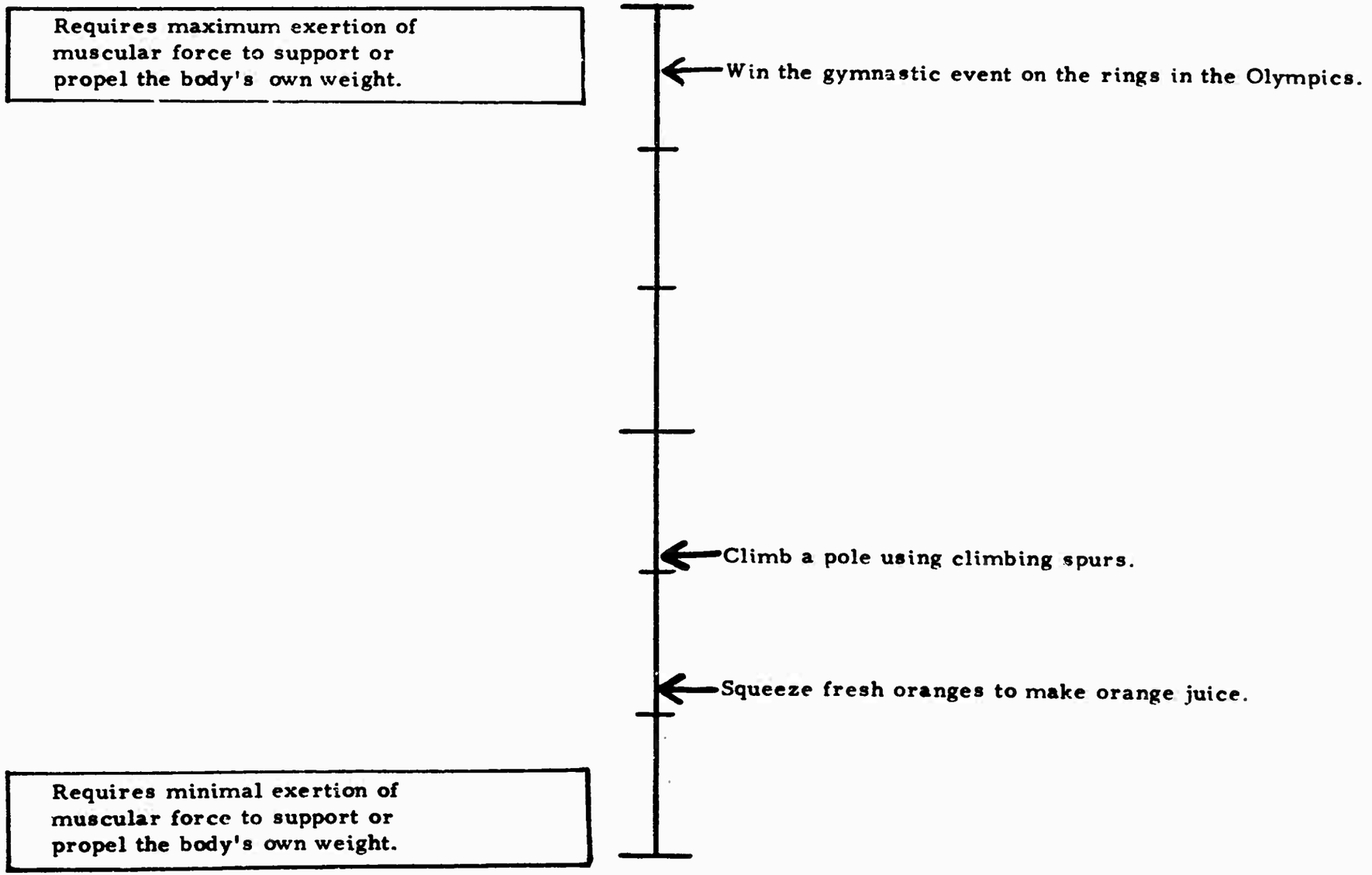
22. DYNAMIC STRENGTH

This ability involves the power of arm and trunk muscles to repeatedly, or continuously support or move the body's own weight. Emphasis is on resistance of the muscles to performance decrement when put under repeated or continuous stress.

DYNAMIC STRENGTH DISTINGUISHED FROM OTHER ABILITIES:

Involves continuous or repeated stress on arm and trunk muscles to support or move the body's weight and resistance to fatigue of these muscles.	vs.	Static Strength (20): Involves exertion of force against an external object.
		Explosive Strength (21): Involves bursts of energy to propel the body or objects.
		Stamina (23): Involves physical activity over prolonged periods of time; emphasizes resistance of cardiovascular system to fatigue.

22. DYNAMIC STRENGTH



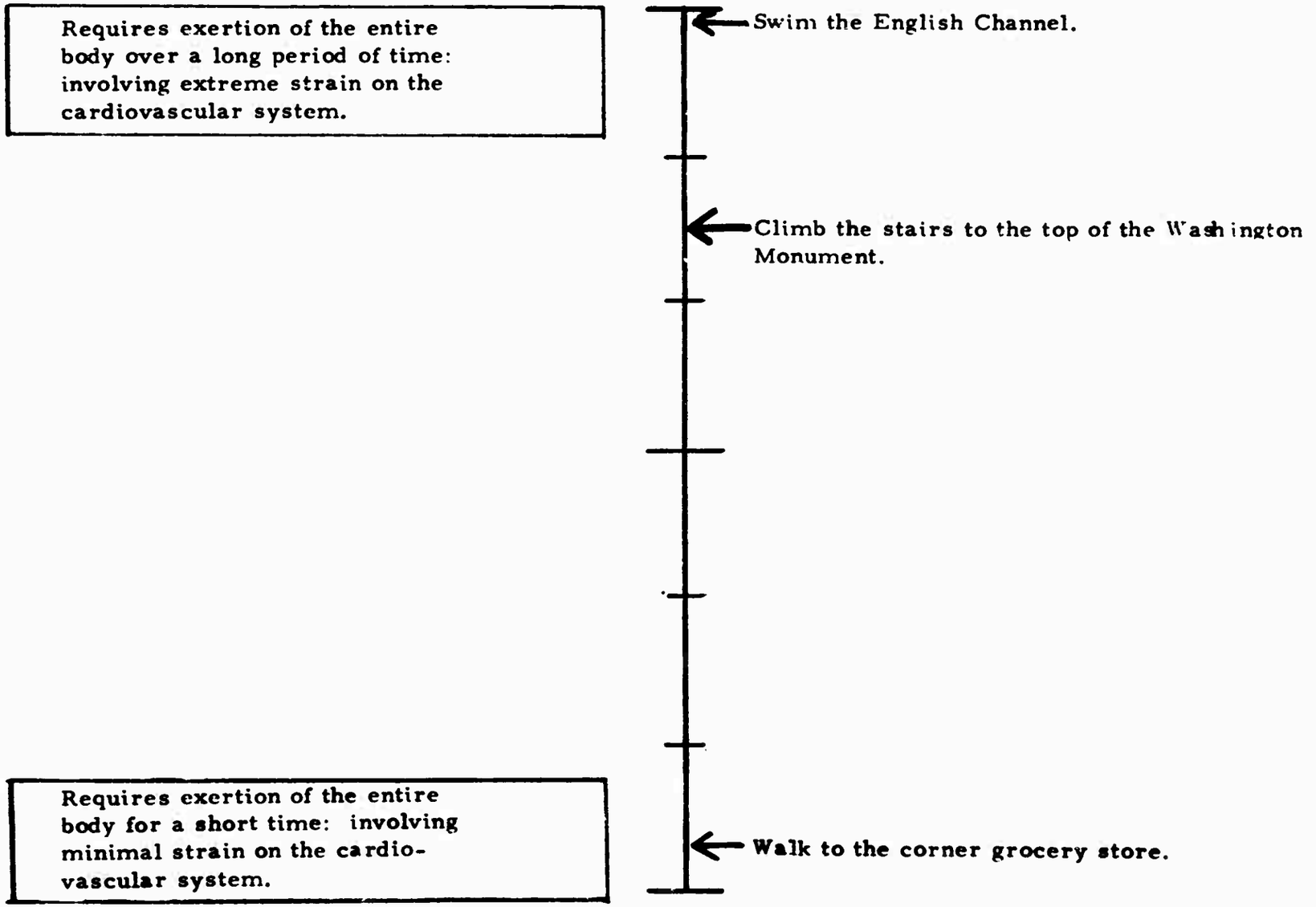
23. STAMINA

This ability involves the capacity to maintain physical activity over prolonged periods of time. It is concerned with resistance of the cardio-vascular system (heart and blood vessels) to breakdown.

STAMINA DISTINGUISHED FROM OTHER ABILITIES:

Involves prolonged physical activity; involves resistance of the cardio-vascular system to breakdown.	vs.	Static Strength (20): Involves exertion of force to lift, push, or pull external objects; does not involve prolonged exertion of force.
		Explosive Strength (21): Bursts of energy to propel body or objects.
		Dynamic Strength (22): Continuous or repeated strain or stress on muscles in supporting body; involves muscular resistance to fatigue.

23. STAMINA


Requires exertion of the entire body over a long period of time: involving extreme strain on the cardiovascular system.
Swim the English Channel.
Climb the stairs to the top of the Washington Monument.
Requires exertion of the entire body for a short time: involving minimal strain on the cardio-vascular system.
Walk to the corner grocery store.

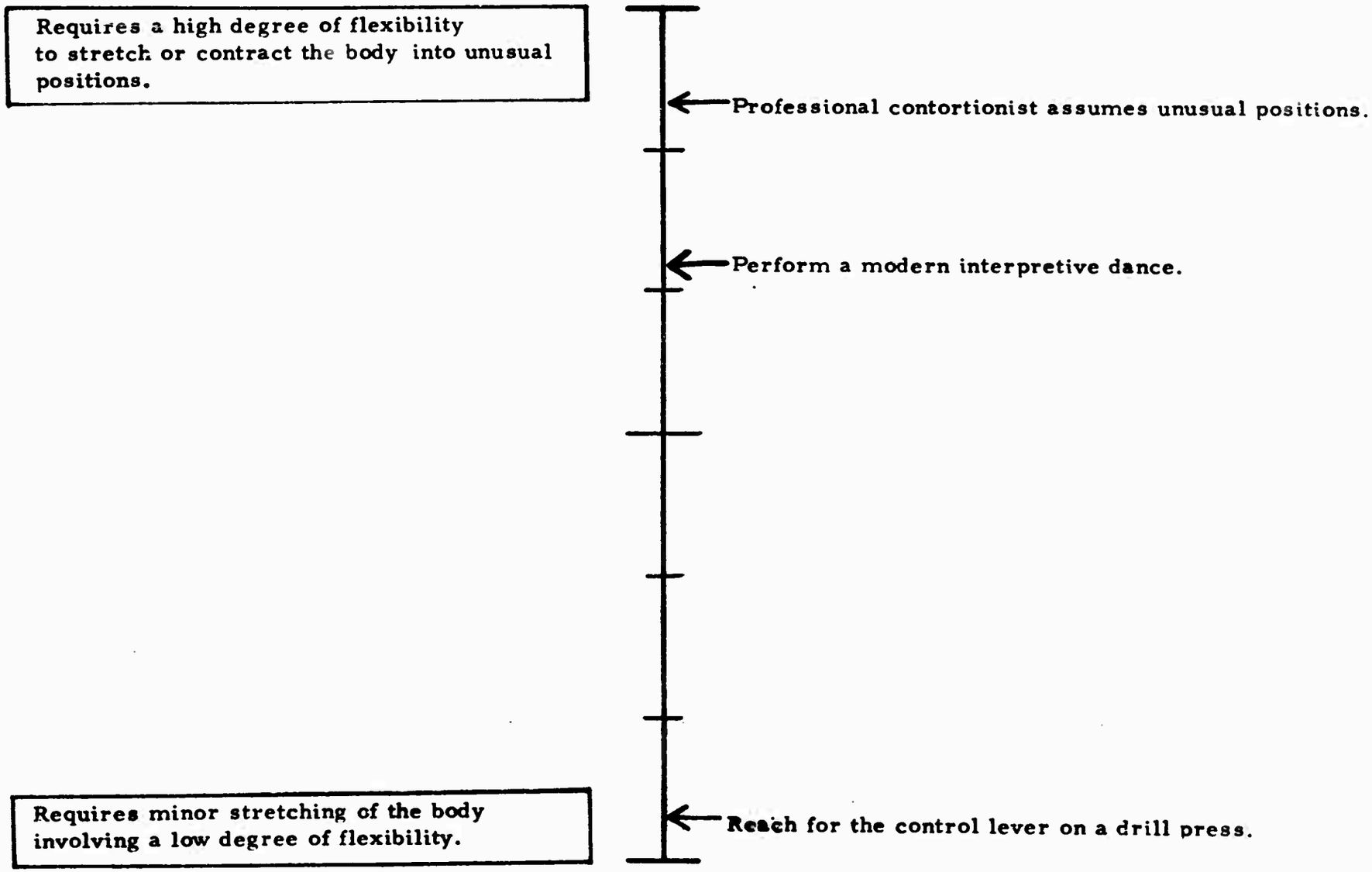
24. EXTENT FLEXIBILITY

This is the ability to extend, flex, or stretch muscle groups. It concerns the degree of flexibility of muscle groups, but does not include repeated or speeded flexing.

EXTENT FLEXIBILITY DISTINGUISHED F. OM OTHER ABILITIES:

Involves degree of flexibility; does not involve repeated or speeded flexing.	vs.	Dynamic Flexibility (25): Does involve repeated and speeded flexing.

24. EXTENT FLEXIBILITY



25. DYNAMIC FLEXIBILITY

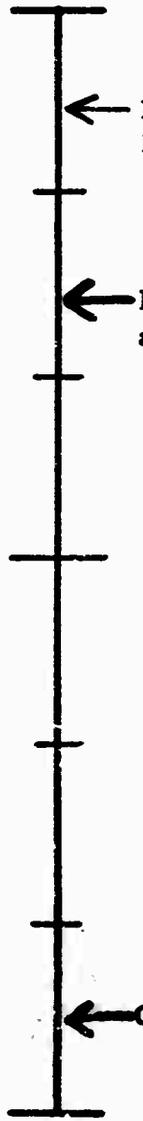
This is the ability to make repeated trunk and/or limb flexing movements where both speed and flexibility of movement are required. It includes the ability of these muscles to recover from the strain and distortion of repeated flexing.

DYNAMIC FLEXIBILITY DISTINGUISHED FROM OTHER ABILITIES:

Involves speed of repeated flexing movements.	vs.	Extent Flexibility (24): Requires no speed, simply extent of flexing possible in a single stretching movement.
Includes ability of muscles to recover from strain and distortion of repeated flexing.	vs.	Stamina (23): Involves prolonged physical activity, involves cardio-vascular resistance to fatigue.

25. DYNAMIC FLEXIBILITY

Requires many rapid and repeated trunk or limb movements involving a high degree of flexibility. Resiliency of the muscles in recovering from the strain of these repeated movements is emphasized.



← Engage in a professional prize fight which lasts 10 rounds.

← Dig a ditch 3 feet X 6 feet X 3 feet with a pick and shovel in 1/2 hour.

Requires few repeated trunk or limb movements involving minimal flexibility where there is minimal time pressure for performance.

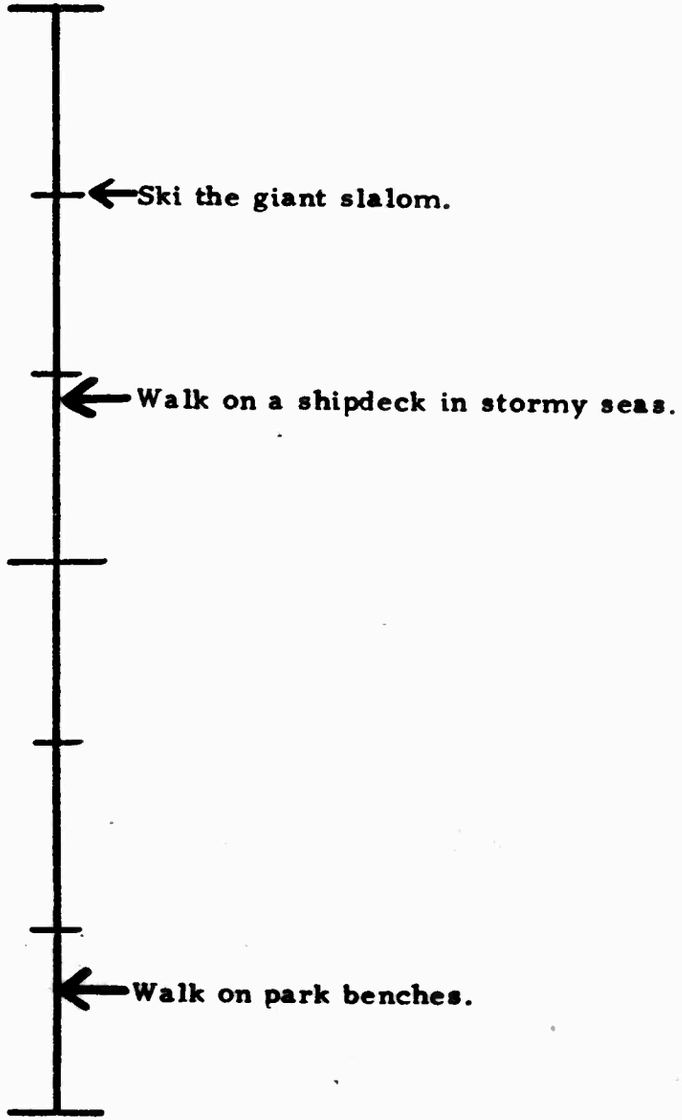
← Crawl on the floor.

26. GROSS BODY EQUILIBRIUM

This is the ability to maintain the body in an upright position or to regain body balance especially in situations where equilibrium is threatened or temporarily lost. This ability involves only body balance; it does not extend to the balancing of objects.

26. GROSS BODY EQUILIBRIUM

Requires the maintenance or re-establishment of body balance despite multiple and complex forces which are continuously operating against the maintenance of balance. These forces operate randomly in that the operator cannot predict either the next force to act upon him, or its duration and strength.



Requires the maintenance or re-establishment of body balance to overcome a single, predictable low intensity force operating against the maintenance of body balance.

27. CHOICE REACTION TIME

This is the ability to select and initiate the appropriate response relative to a given stimulus in the situation where two or more stimuli are possible and where the appropriate response is selected from two or more alternatives. The ability is concerned with the speed with which the appropriate response can be initiated and does not extend to the speed with which the response is carried out. This ability is independent of mode of stimulus presentation (auditory or visual) and also of type of response required.

CHOICE REACTION TIME DISTINGUISHED FROM OTHER ABILITIES:

Involves speed of response initiation when response involves selection from two or more alternatives relative to two or more stimuli.	vs.	Reaction Time (28): Involves speed of response initiation when there is a single response associated with a single stimulus.
		Speed of Limb Movement (29) and Wrist Finger Speed (30): Deal with the speed with which a movement or response can be made once initiated.

27. CHOICE REACTION TIME

Requires the selection of the correct response from many alternatives and the initiation of the response with such extreme speed that it could be expected from only an extremely limited number of people.

In a space craft out of control, an astronaut has time to choose only 1 of 5 possible corrective actions in 0,7 seconds.

Operate a busy PBX or switchboard where you start to answer each call in 1 second on the average.

Select the correct fork in the road when the road sign is located at the center of the fork itself and where you have 1 second to make your choice.

Requires only enough speed to select the correct response from two alternatives and to initiate that response when time constraints are minimal.

28. REACTION TIME

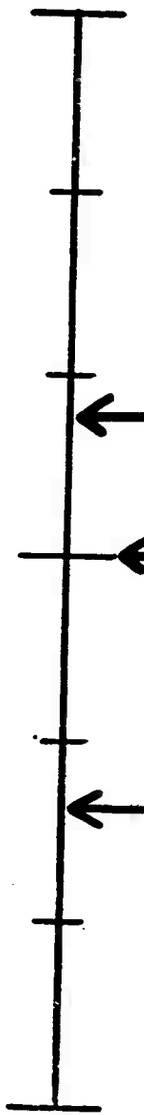
This ability involves the speed with which a single motor response can be initiated after the onset of a single stimulus. It does not include the speed with which the response or movement is carried out. This ability is independent of the mode of stimulus presentation (auditory or visual) and also of the type of motor response required.

REACTION TIME DISTINGUISHED FROM OTHER ABILITIES:

Deals with the speed with which a single motor response can be initiated relative to a single stimulus.	vs.	Choice Reaction Time (27): Involves speed of response initiation when response involves selection from two or more alternatives relative to two or more stimuli.
		Speed of Limb Movement (29) and Wrist Finger Speed (30): Deal with the speed with which a movement or response can be made once initiated.

28. REACTION TIME

Requires the initiation of a motor response with such extreme quickness that it could be expected only from a very limited number of people.



In 0.2 seconds, correct having stepped on the gas when you really meant to step on the brake.

Batter evades a fast ball thrown inside.

Start to apply the brakes on your car 1 second after seeing the red light.

Requires only enough speed in initiation of movement to respond within a relatively long period of time.

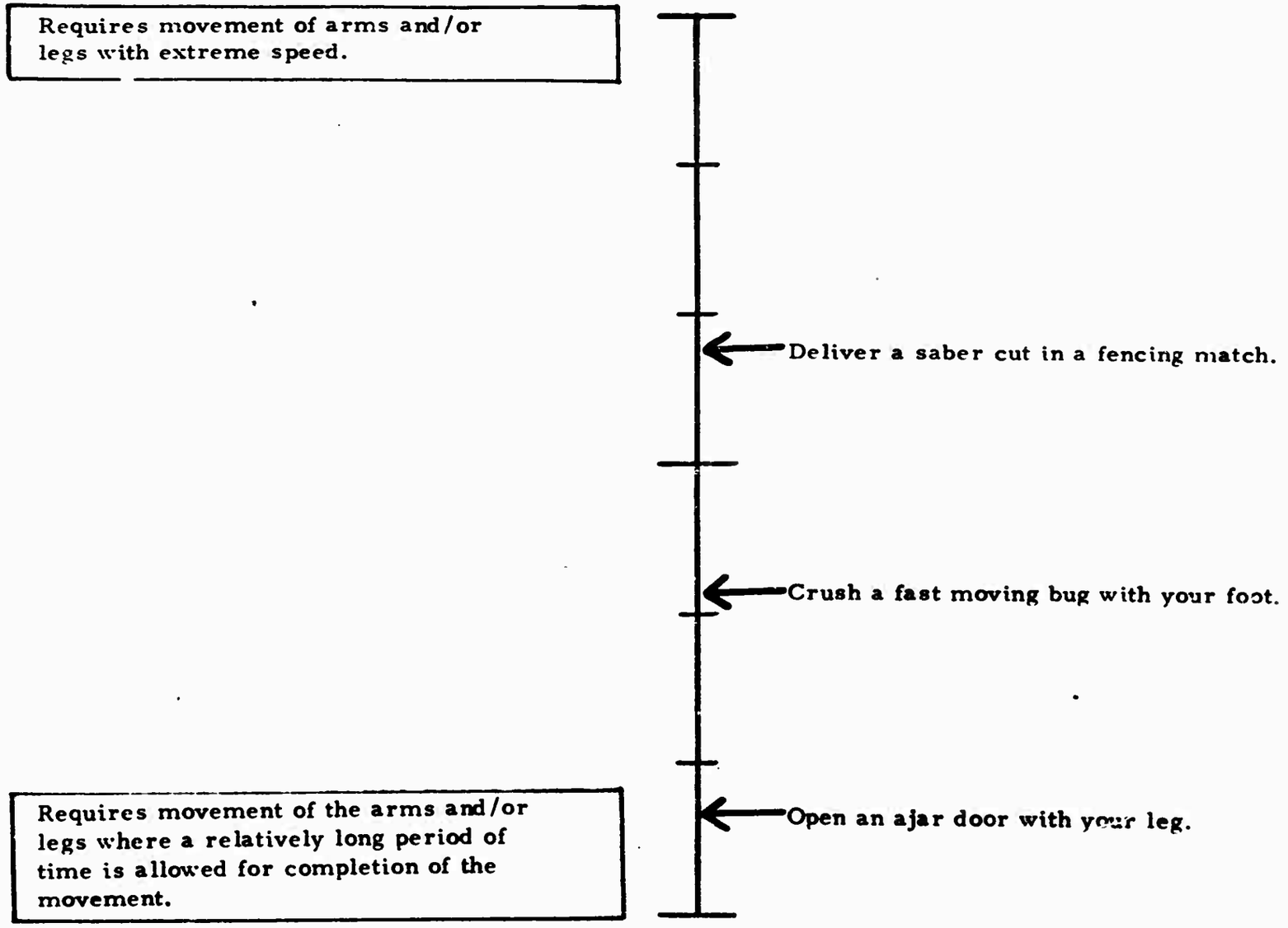
29. SPEED OF LIMB MOVEMENT

This ability involves the speed with which discrete movements of the arms or legs can be made. The ability deals with the speed with which the movement can be carried out after it has been initiated; it is not concerned with the speed of initiation of the movement. In addition, the precision, accuracy and coordination of the movement is not considered under this ability.

SPEED OF LIMB MOVEMENT DISTINGUISHED FROM OTHER ABILITIES:

Speed to carry out a movement or response, once initiated.	vs.	Reaction Time (28) and Choice Reaction Time (27): Involve speed of response initiation.
Speed of movement of arms or legs.	vs.	Wrist-Finger Speed (30): Speed of movement of fingers, hands, and wrists.
Speed of movement of arms.	vs.	Manual Dexterity (34): Skilled, controlled arm-hand movements.

29. SPEED OF LIMB MOVEMENT



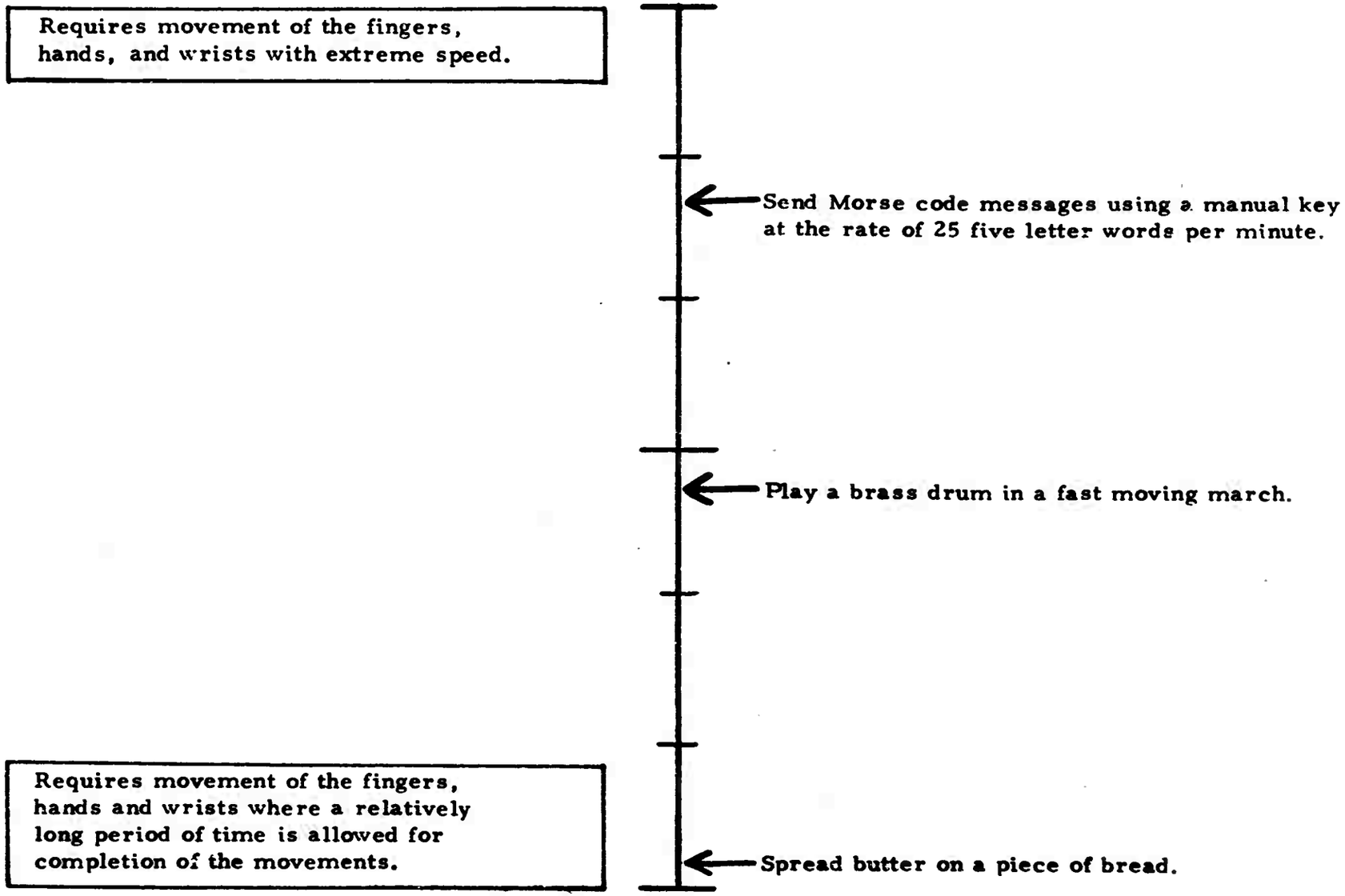
30. WRIST-FINGER SPEED

This ability is concerned with the speed with which discrete movements of the fingers, hands, and wrists can be made. The ability is not concerned with the speed of initiation of the movement. It is only concerned with the speed with which the movement is carried out. This ability does not consider the question of the accuracy of the movement; nor does it depend upon precise eye-hand coordination.

WRIST-FINGER SPEED DISTINGUISHED FROM OTHER ABILITIES:

Speed of movement of fingers, hands and wrists.	vs.	Finger Dexterity (33): Skillful, controlled finger movements. Manual Dexterity (34): Skillful, controlled arm-hand movements.
Speed to carry out a movement or response, once initiated.	vs.	Reaction Time (28) and Choice Reaction Time (27): Involves speed of response initiation.

30. WRIST-FINGER SPEED



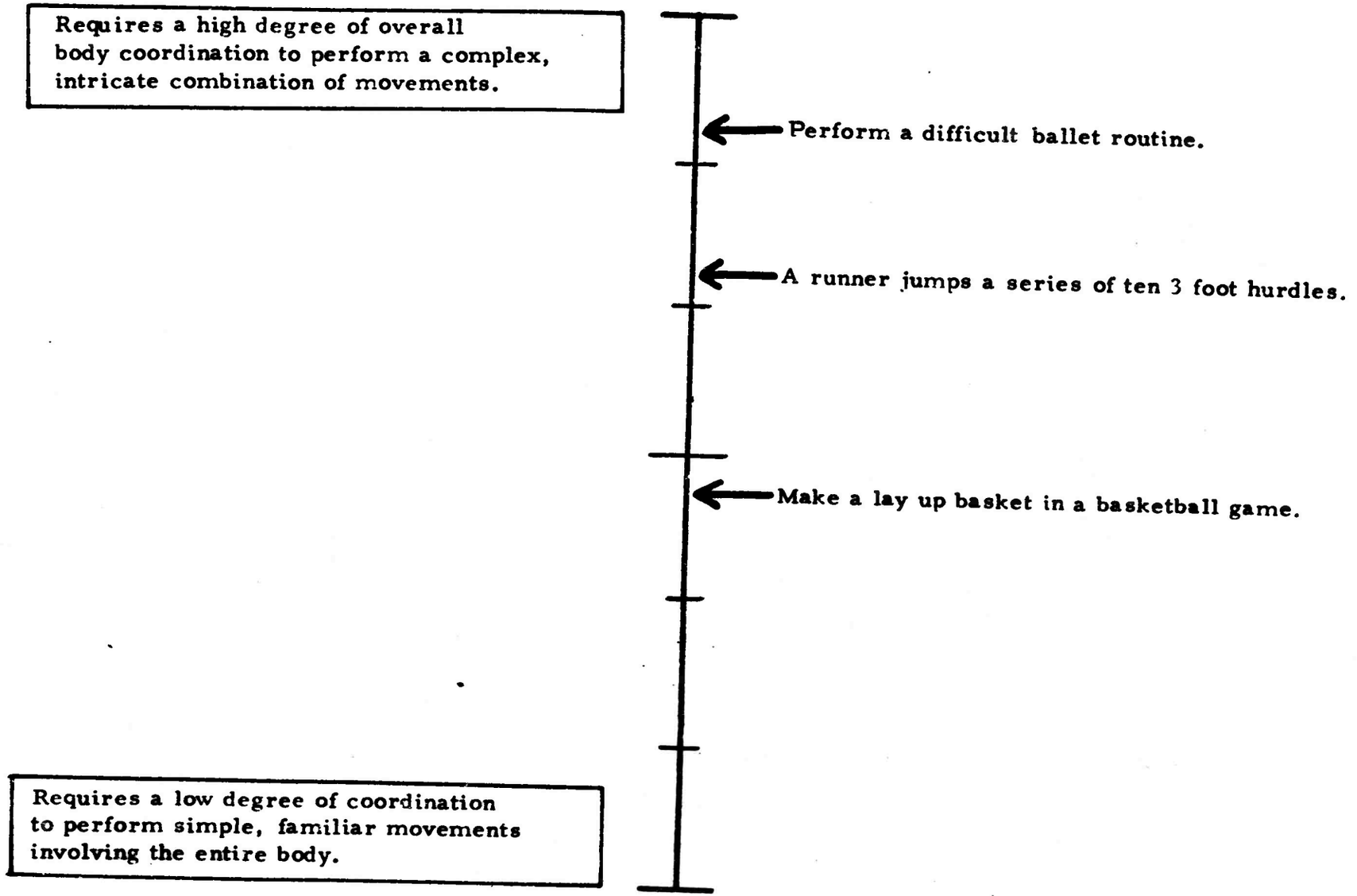
31. GROSS BODY COORDINATION

This is the ability to coordinate movements of the trunk and limbs. This ability is most commonly found in situations where the entire body is in motion or being propelled.

GROSS BODY COORDINATION DISTINGUISHED FROM OTHER ABILITIES:

Involves the coordination of the entire body including the trunk.	vs.	Multilimb Coordination (32): Involves coordination of two or more limbs; does not extend to trunk movement.

31. GROSS BODY COORDINATION



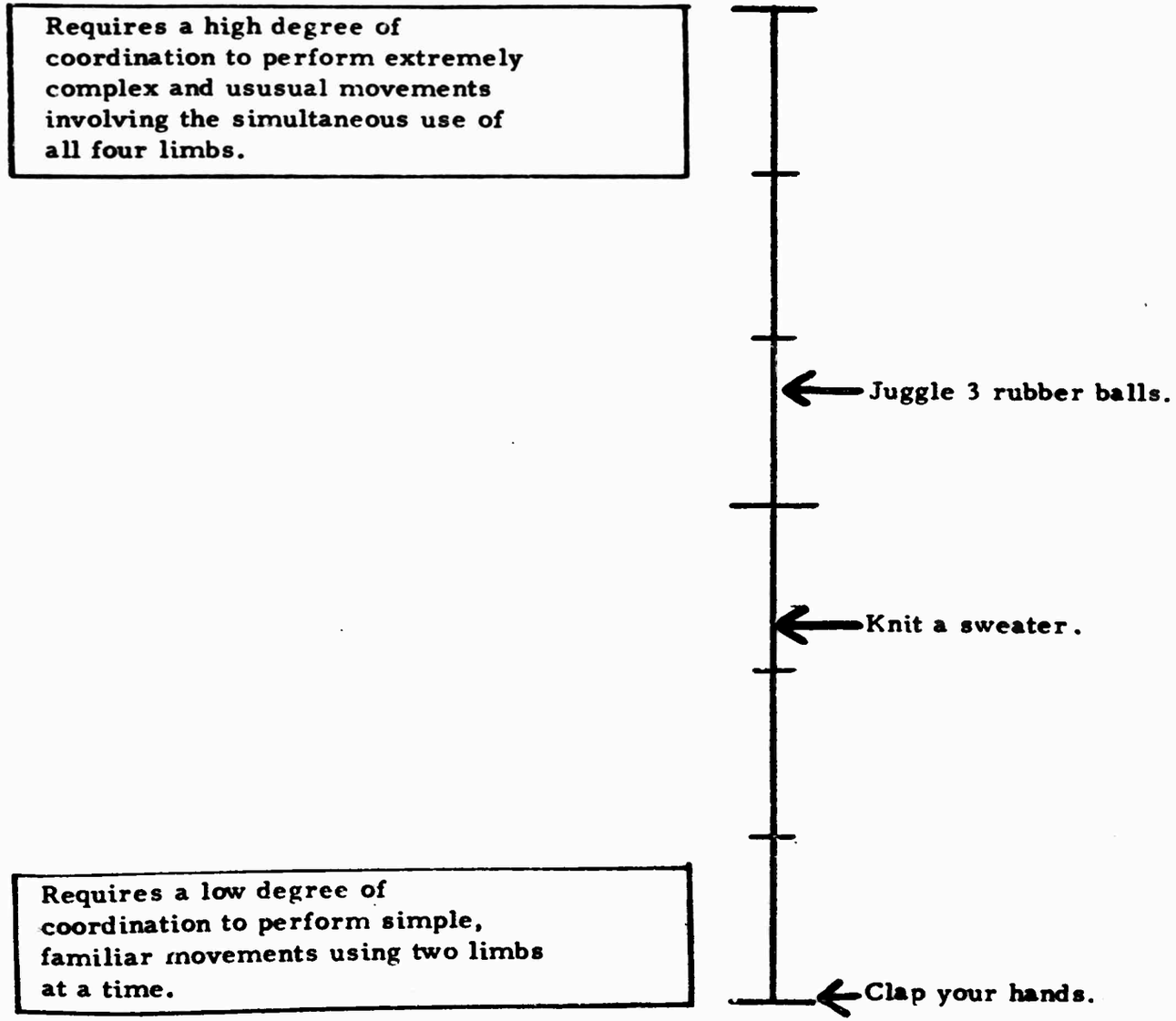
32. MULTILIMB COORDINATION

This is the ability to coordinate the movements of two or more limbs (e.g., two legs, two hands, one leg, and one hand). The ability does <u>not</u> apply to tasks in which trunk movements must be integrated with limb movements. It is most common to tasks where the body is at rest (e.g., seated or standing) while two or more limbs are in motion.

MULTILIMB COORDINATION DISTINGUISHED FROM OTHER ABILITIES:

Involves coordination of <u>two</u> or more limbs (e.g. arms and hands).	vs.	Manual Dexterity (34): Involves coordination of a <u>single</u> hand or of hand together with its arm.
Involves coordination of two or more limbs; does <u>not</u> extend to <u>trunk</u> movement.	vs.	Gross Body Coordination (31): Involves the coordination of the entire body <u>including the trunk</u>.

32. MULTILIMB COORDINATION



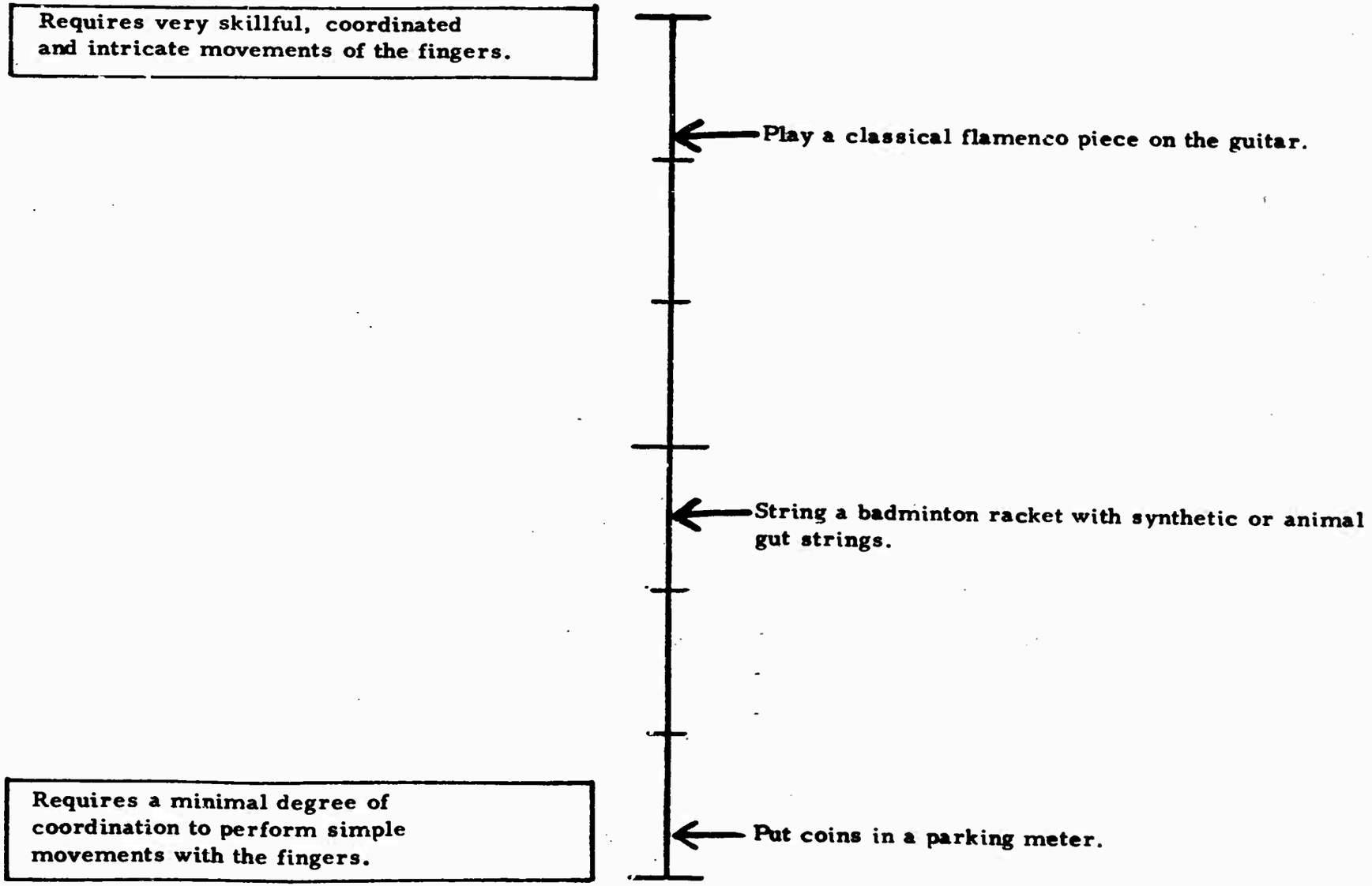
33. FINGER DEXTERITY

This is the ability to make skillful, coordinated movements of the fingers where manipulations of objects may or may not be involved. This ability does not extend to manipulation of machine or equipment control mechanisms. Speed of movement is not involved in this ability.

FINGER DEXTERITY DISTINGUISHED FROM OTHER ABILITIES:

Skilled movements involving primarily the fingers.	vs.	Manual Dexterity (34): Skilled movements involving mainly the arm and hand.
Can involve manipulations of objects.	vs.	Rate Control (36) and Control Precision (37): Involves the manipulation of machine or equipment controls.

33. FINGER DEXTERITY



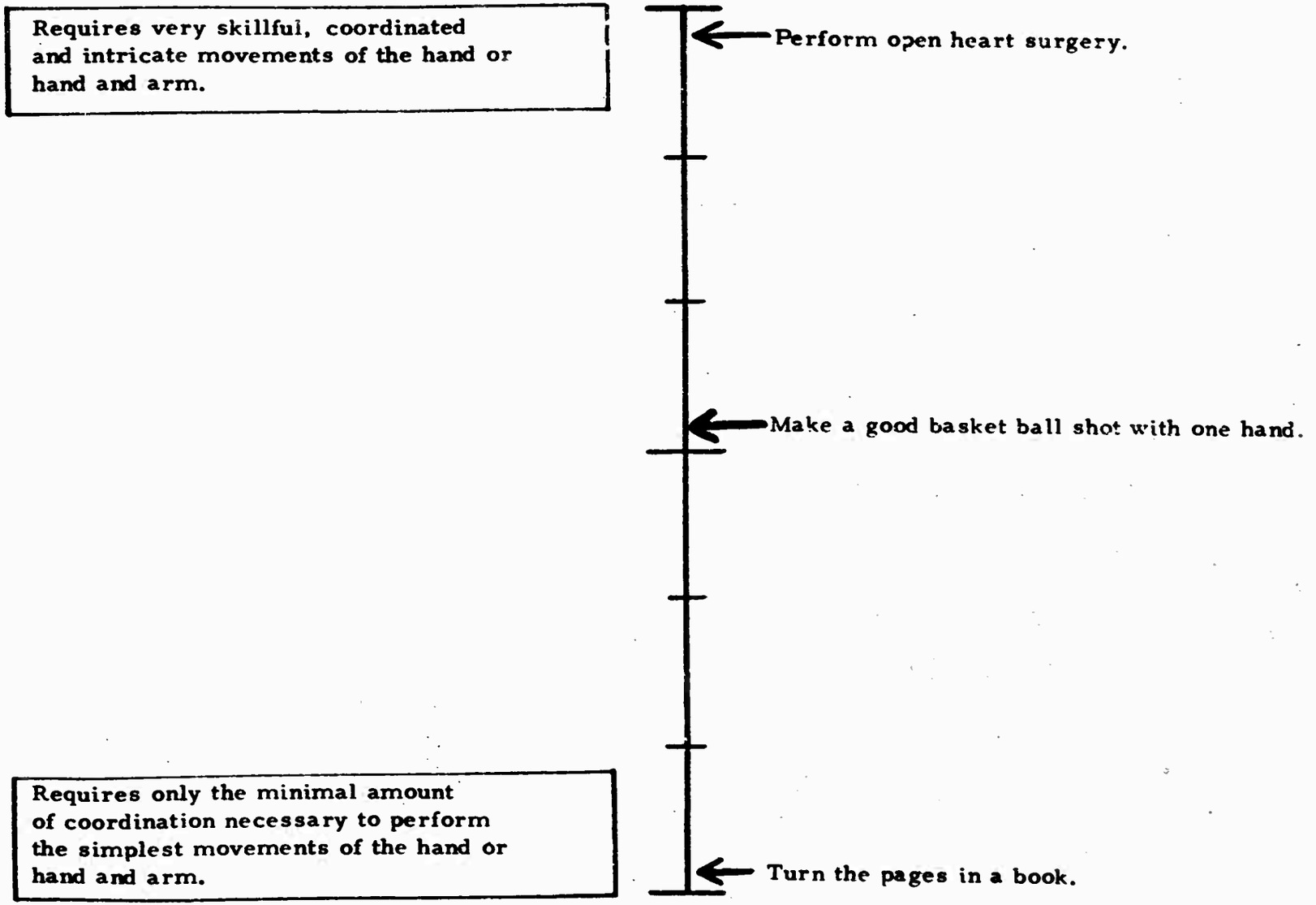
34. MANUAL DEXTERITY

This is the ability to make skillful, coordinated movements of a hand, or of a hand together with its arm. This ability is concerned with coordination of movement within the limb. It may involve manipulation of objects (e.g., blocks, pencils), but does not extend to machine or equipment controls (e.g., levers, dials).

MANUAL DEXTERITY DISTINGUISHED FROM OTHER ABILITIES:

Involves the coordination of movement.	vs.	Arm-Hand Steadiness (35) Involves steadiness in positioning or aiming.
Can involve the manipulation of objects.	vs.	Rate Control (36) and Control Precision (37): Involves the manipulation of machine or equipment controls.
Skilled movements involving mainly the hand and arm	vs.	Finger Dexterity (33): Skilled movements involving primarily the fingers.
Involves coordination of a single hand or of a hand together with its arm.	vs.	Multilimb Coordination (32): Involves coordination of two or more limbs (e.g., two arms, two hands).

34. MANUAL DEXTERITY



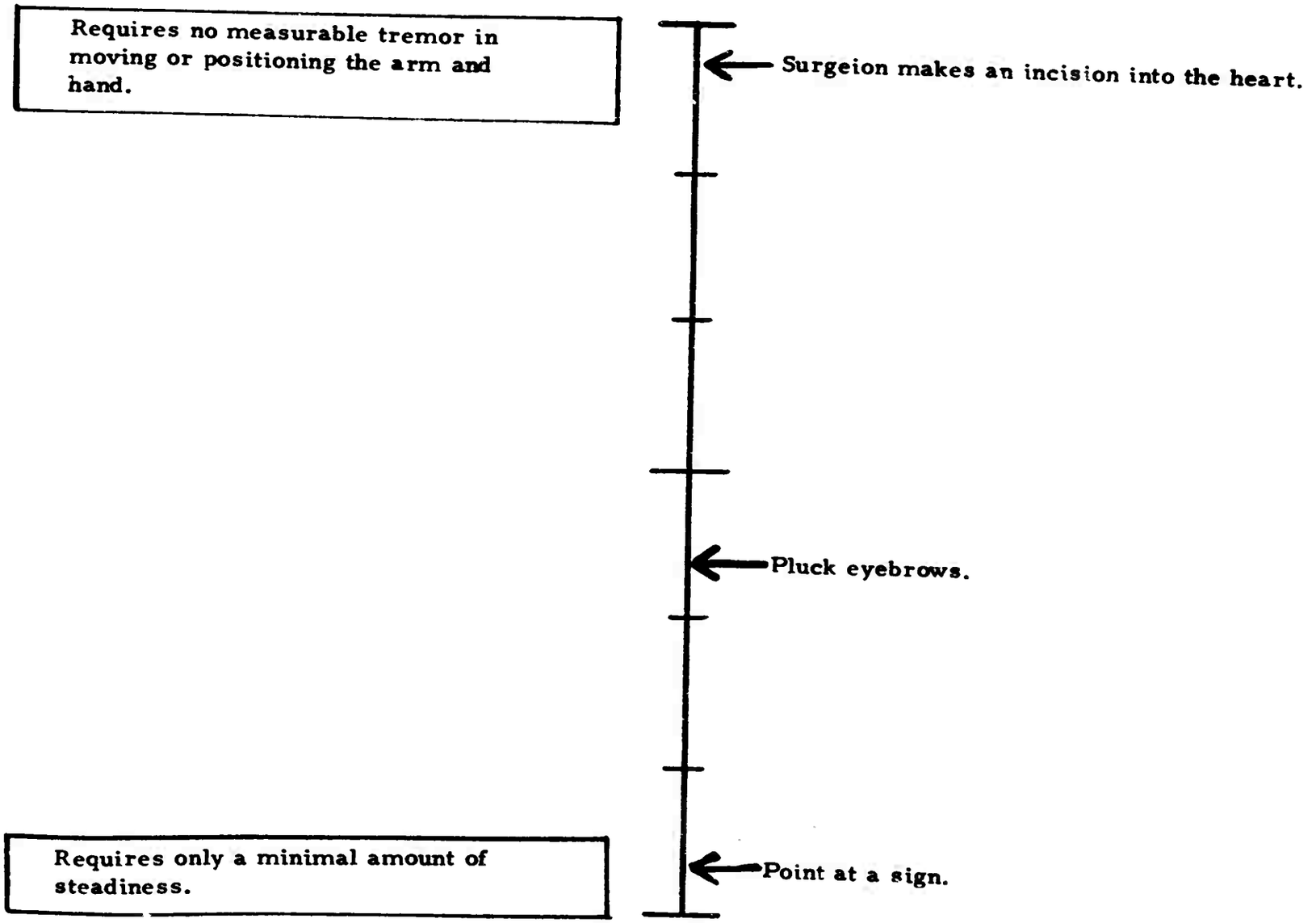
35. ARM-HAND STEADINESS

This is the ability to make precise, steady arm-hand positioning movements where both strength and speed are minimized. It includes steadiness during movement as well as minimization of tremor and drift while maintaining a static arm position. This ability does not extend to the adjustment of equipment controls (e.g., levers, dials).

ARM-HAND STEADINESS DISTINGUISHED FROM OTHER ABILITIES:

Involves positioning movements where objects may or may not be involved.	vs.	Rate Control (36) and Control Precision (37): Involves positioning and manipulation of machine or equipment controls.
Involves steadiness in positioning or aiming.	vs.	Manual Dexterity (34): Involves coordination of movement within a hand and arm.

35. ARM-HAND STEADINESS



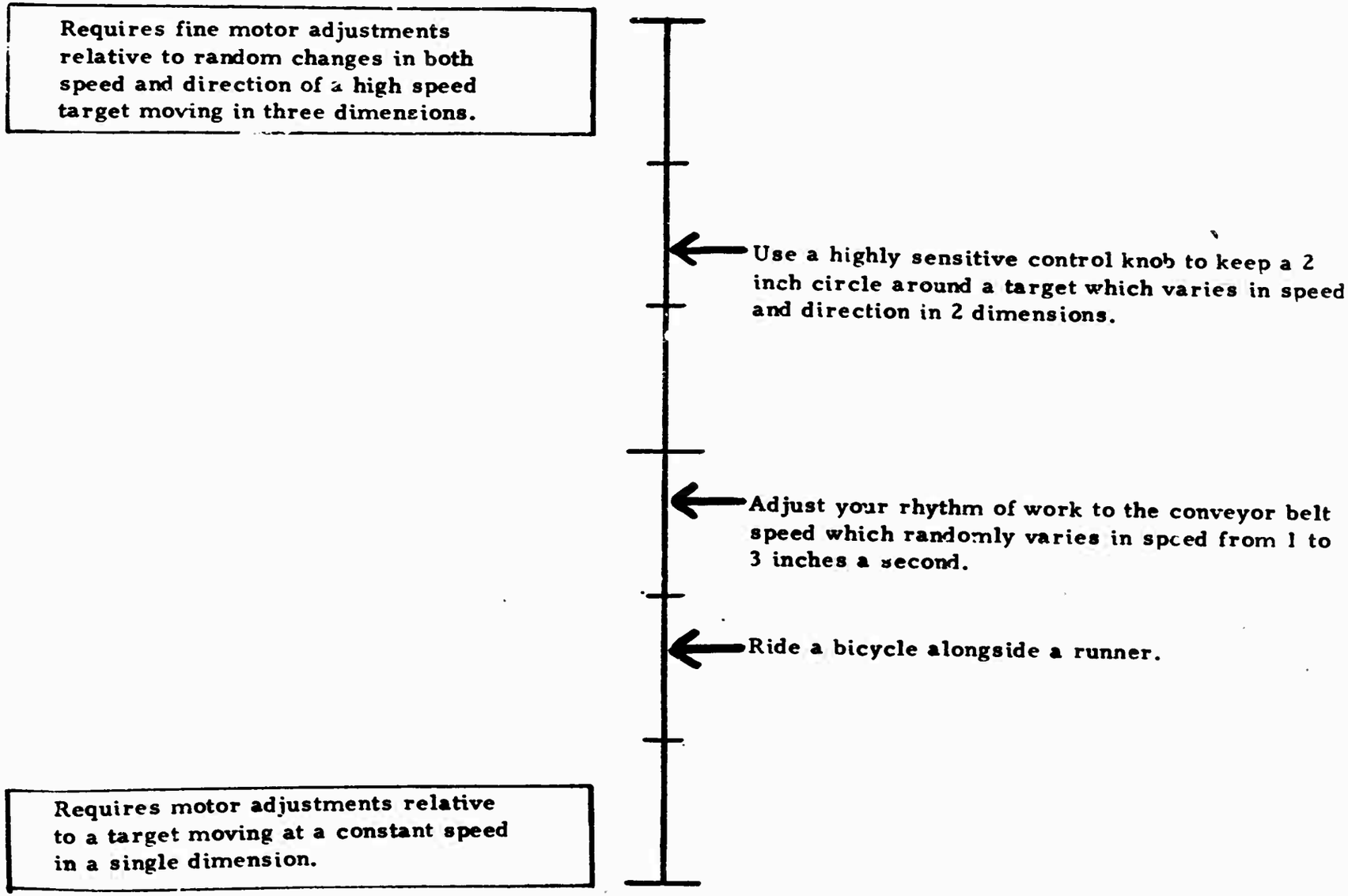
36. RATE CONTROL

This is the ability to make timed, anticipatory motor adjustments relative to changes in the speed and/or direction of a continuously moving object. The purpose of the motor adjustments is to intercept or follow a continuously moving stimulus whose speed and/or direction vary in an unpredictable fashion. This ability does not extend to situations in which both the speed and direction of the object are perfectly predictable.

RATE CONTROL DISTINGUISHED FROM OTHER ABILITIES:

Always involves a moving object whose speed and/or direction are unpredictable.	vs.	Control Precision (37): Involves a moving object whose speed and direction are perfectly predictable.
Involves the manipulation and positioning of machine or equipment controls.	vs.	Arm-Hand Steadiness (35): Involves positioning movements where objects may or may not be involved. Manual Dexterity (34): Involves coordination of movement where objects may or may not be involved.

36. RATE CONTROL



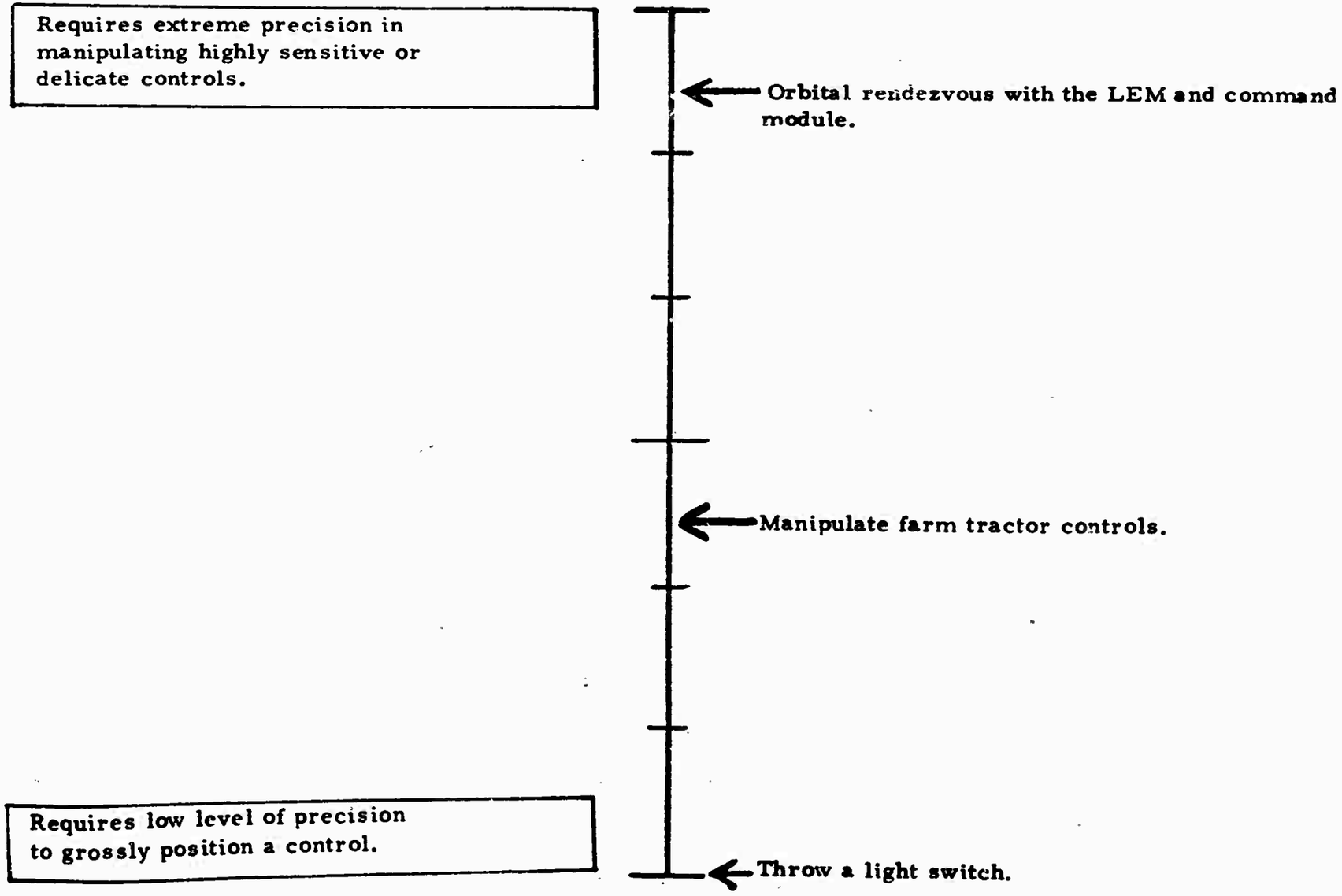
37. CONTROL PRECISION

This is the ability to make controlled muscular movements necessary to adjust or position a machine or equipment control mechanism. The adjustments can be anticipatory motor movements in response to changes in the speed and/or direction of a moving object whose speed and direction are perfectly predictable.

CONTROL PRECISION DISTINGUISHED FROM OTHER ABILITIES:

Can involve a moving object whose speed and direction are perfectly predictable.	vs.	Rate Control (36): Always involves a moving object whose speed and/or direction are not predictable.

37. CONTROL PRECISION



TASK DESCRIPTION #1

A 21 year old female student is going to drive a 1968 Chevrolet Impala during rush hour traffic (approximately 5:30). The trip will begin at the University of Maryland and will end at the Hecht Co. in Silver Spring. This car that she will be driving has a manual transmission (stick shift, 4 on the floor) and power steering but no power brakes.

She unlocks her car, gets in and turns the ignition on. Before backing up she fastens her seat belt and turns the radio on. She backs out of her parking space in Lot 1 and makes a right turn onto University Blvd. Next, she makes a right turn onto the approach to Route 1 and proceeds toward the Capital Beltway. Frequent stops and starts are made on the way to the Beltway because traffic is heavy. Upon arriving at the Beltway, she must quickly pull out from the ramp to get into the main traffic stream.

She is driving in the right hand lane at 50 mph and notices an accident up ahead, so she must quickly pull into the center lane. The rest of the driving on the Beltway is marred by two quick panic stops.

She gets off at Georgia Avenue and continues down it toward Silver Spring. She is traveling at 30 mph in light to medium traffic with occasional stops and starts or traffic lights.

After arriving at the Hecht Co., she finds an empty parking space between two parked cars and must parallel park.

TASK DESCRIPTION #2

A simulated approach-control task was used in which subjects (Ss) served as radar controllers (RCs) who were responsible for directing aircraft through an approach gate. The approaches were to be effected at a prescribed rate, and two Ss were required to alternate in controlling approaches. That is, the first approach was to be directed by RC_1, the second by RC_2, and then RC_1 assumed responsibility for the third incoming aircraft, and so on.

The RCs delivered instructions to pilots over a voice-communication channel, and the pilots carried out the instructions faithfully and without delay by appropriate manipulation of their consoles. The RC-to-pilot communication protocol required that the RC first identify the pilot and then issue the command, for example, "Bravo one, speed 200 knots"; in return, the pilot was to immediately confirm the command, for example, "Roger, Bravo one, speed 200 knots." The RCs gave only heading and speed commands to the pilots; altitude was intentionally omitted from consideration in order to maintain a reasonable level of task difficulty.

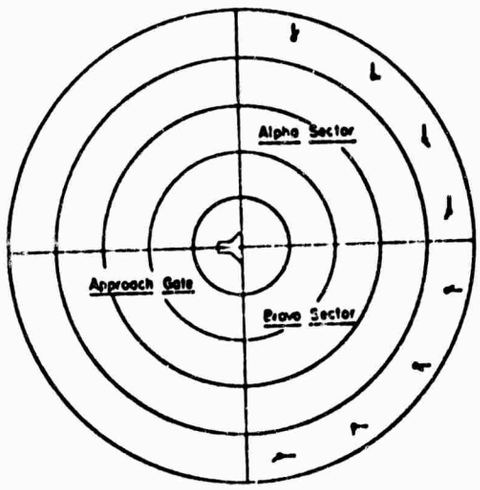


Fig. 1. Reproduction of the display at the start of a session.

The radar display as it appeared at the beginning of a session is reproduced in Figure 1. The approach gate was located precisely at the center of the displayed airspace, and all aircraft entered the airspace from the eastern (right-hand) periphery. The display was marked with concentric rings, and the distance between adjacent rings represented 20 mi. The distance from the periphery to the approach gate represented 100 mi The aircraft appearing in the northeast sector of the scope were designated as "Alpha" aircraft, and those appearing in the southeast sector were referred to as "Bravo" aircraft. The Alpha and Bravo aircraft were indicated by different codes. The RCs were not allowed to write down the specific codes for any of the planes. The two RCs monitored the same airspace but on different displays, and they could speak to one another only over a voice-communication channel. The Alpha RC was assigned to the Alpha aircraft, the Bravo RC to the Bravo aircraft.

At the beginning of a session, four Alpha aircraft were spaced evenly along the eastern periphery of the airspace. An Alpha aircraft made the first approach, a Bravo aircraft followed, the another Alpha aircraft, and so on. A successful approach occurred when an aircraft entered the approach gate at 200 kn. on a heading of 270°. A "miss" occurred if an aircraft in the inner circle of the display crossed the longitudinal axis into the western half of the airspace in any condition not constituting a successful approach.

Within a sector, the planes could fly at any heading specified by the RC as long as the final approach was made at a heading of 270° and a speed of 200 kn. The RCs could do simple computations where necessary to aid them in directing their aircraft. The required approach rate (system criterion) was an approach every 2 min. A compensatory arrangement was employed. That is, a given approach was to compensate for the accumulated time error. Hence, if a time error of 20 sec. late had acrued over prior approaches, the next approach was to be 20 sec. early so that the average of the approach times would equal the system criterion of 2 min.

A clock system was mounted on the wall in front of the team in such a way that the RCs could keep continuous track of their temporal progress in guiding aircraft through the approach gate. Each clock kept time in terms of minutes and seconds up to 1 hour, and could be viewed by only a slight shift in an RCs line of vision from the input display.

The following aspects of the task characterized both team arrangements: (a) A small red light indicated whose turn it was to effect an approach; (b) the timing started upon the completion of the first approach of the session; and (c) immediate feedback was provided to the RC team of time errors (relative to the compensatory or non-compensatory criteria), misses, and safety infractions immediately after each approach except the first.

TASK DESCRIPTION #3

SHEET METAL WORKER: USING HAND LEVER PUNCH

1. Marks point on sheet metal where punch hole is to be made.
2. Selects appropriate punch and die to be used.
3. Unscrews die with screwdriver or key furnished with the punch.
4. Opens punch by lifting lever.
5. Unscrews threaded collar.
6. Lifts punch from collar (if other one is there).
7. Inserts desired punch in collar.
8. Screws on threaded collar
9. Depresses lever to normal position.
10. Inserts and screws desired die into position.
11. Turns die so that the end of the punch enters the die approximately 1/16" when levers are in normal or closed position.
12. Opens punch.
13. Inserts sheet metal into punch.
14. Centers punch (centering point of punch is placed in the prick point made during layout).
15. Presses down on lever to punch hole.
16. Opens punch by lifting lever.
17. Visually inspects size and appearance of punched hole.

TASK DESCRIPTION #4

In order to perform the task to be described, it is necessary to understand some orbital dynamics concepts.

See Figure 1.

The first figure shows a space vehicle in orbit around the earth. Orbit 1 is a circular orbit. If a retrograde or slowing down thrust is applied as shown in the figure, elliptical trajectories result. Orbit 2 is such an ellipse. As the vehicle falls toward the earth it gains velocity. The increase in velocity is sufficient to cause it to regain altitude, but as it climbs it slows down again resulting in the elliptic path. Orbit 3 results from enough deceleration to cause the vehicle to re-enter the atmosphere before regaining sufficient velocity to climb.

Now look at the second figure. Orbit 1 is again a circular orbit. The thrust applied as shown would cause the vehicle to accelerate and move into orbit 2. This orbit is also an ellipse, since as the vehicle gains altitude, it slows down and begins to fall. As the vehicle falls it gains velocity and begins to climb as in the first case. If a second thrust is applied at the highest point in the orbit (apogee), shown by the dotted line, orbit 3 is attained. This is a circular orbit higher than orbit 1. This is the most efficient way to change orbits. Thrust is used only twice, the remainder of the time is spent coasting. Similar two-impulse transfers exist for any orbit change.

The purpose of these figures is to show what happens when thrust is applied to an orbiting vehicle.

Now look at figure 3a. The circle with the cross in it represents a vehicle in a circular orbit around the earth. Part of the earth can be seen below the vehicle. The figure is now centered on the vehicle and referenced to an imaginary line between the vehicle and the center of the earth. Thus the earth would appear to turn under the vehicle instead of the vehicle turning about the earth. The situation is exactly the same in Figures 1 and 2, only the view is changed. The dotted box surrounds the area of interest for one type of rendezvous. That is the area ahead of and above and below the target vehicle.

See Figure 3b.

Consider the path of a second vehicle attempting to rendezvous with the target vehicle. If the second vehicle is initially directly ahead of the target at the same altitude and speed (shown in Figure 3b) it must slow down to allow the target to catch up. If the interceptor simply slows up he will lose altitude and follow path 1. This path obviously will not allow him to rendezvous with the target. He must thrust upward to maintain his altitude at the same time that he slows down. If the proper combination of thrusts are applied he might follow path 2. All that would remain for him to do would be to accelerate to the same velocity as the target so that at intercept they would have no (zero) relative velocity.

Each subject monitors predictor display on a cathode ray tube. It shows you the interceptor's predicted path for a five minute period. The right hand end of the trace represents the interceptor's present position. The left hand end represents the interceptor's position five minutes in the future. This trace always represents a five minute prediction. As you accelerate and decelerate the trace will appropriately lengthen and shorten. If the interceptor is stopped relative to the target, the trace will become a dot. The curvature of the trace results from the orbital dynamics, discussed above, operating on the interceptor's velocity vector.

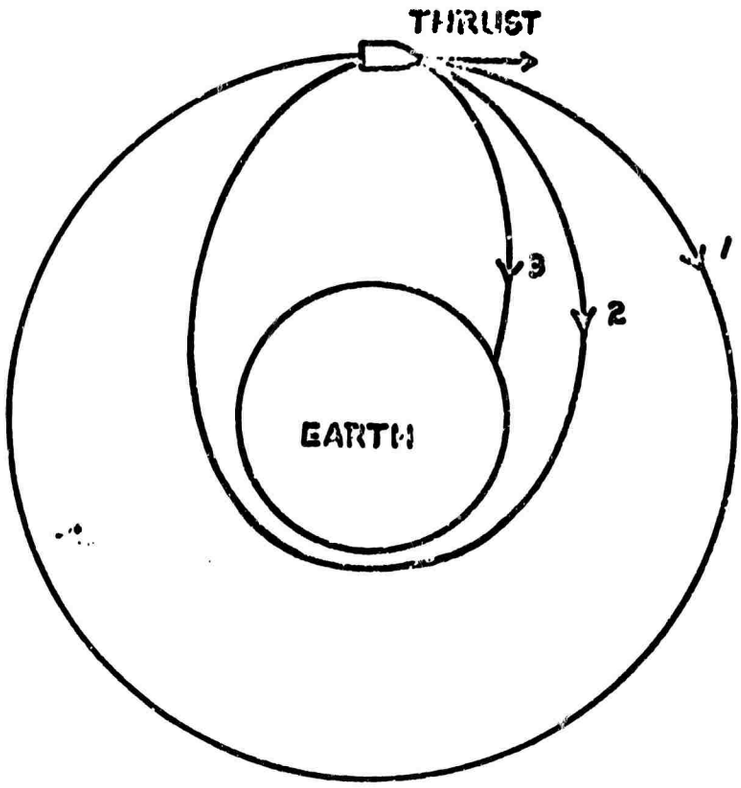


Figure 1

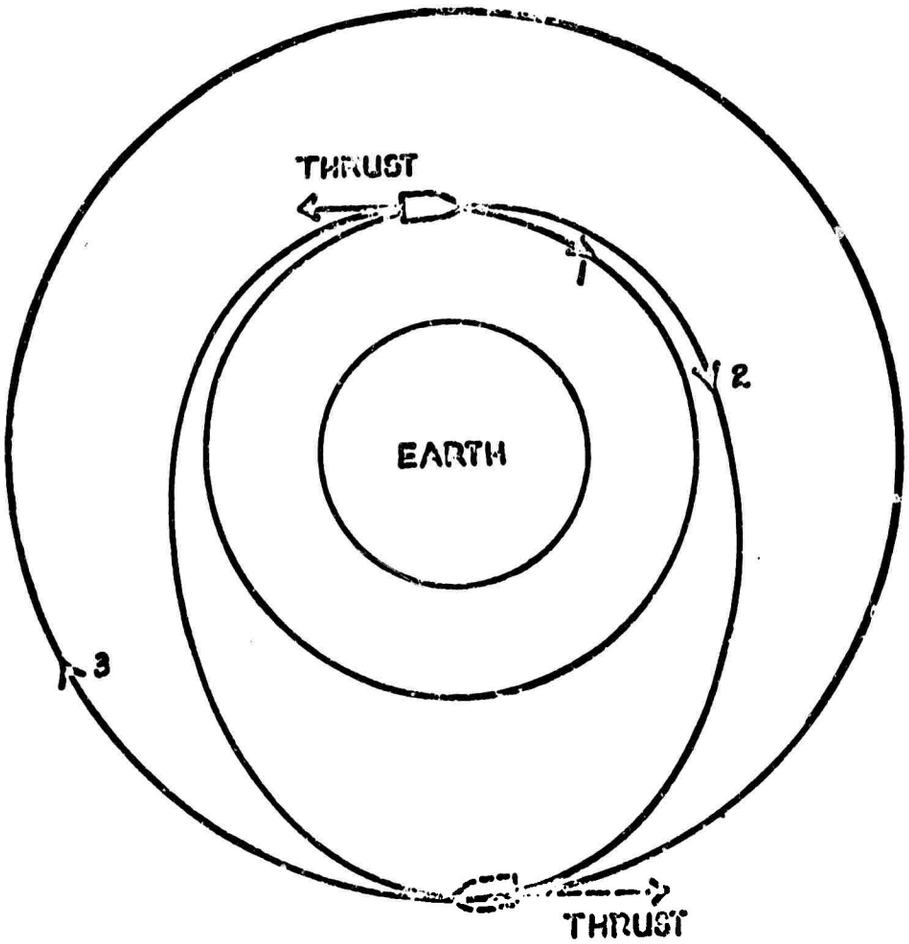


Figure 2

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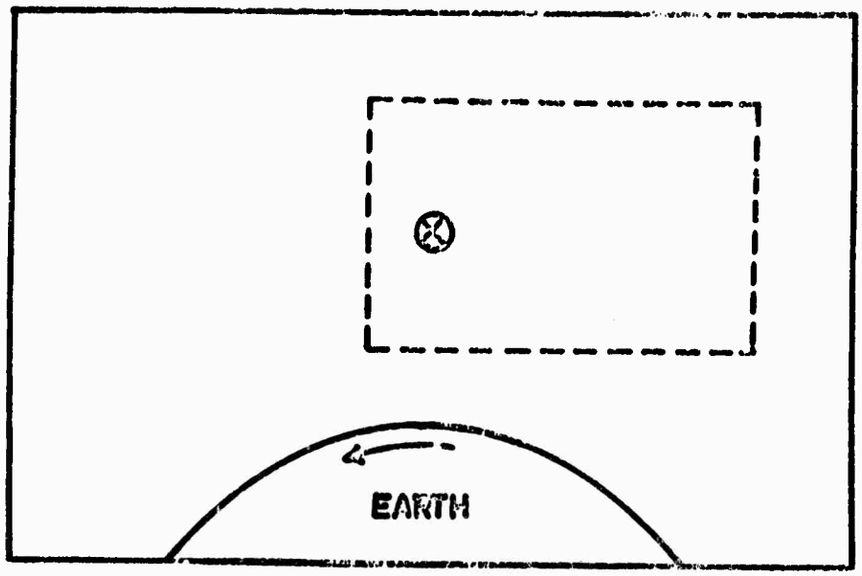


Figure 3a

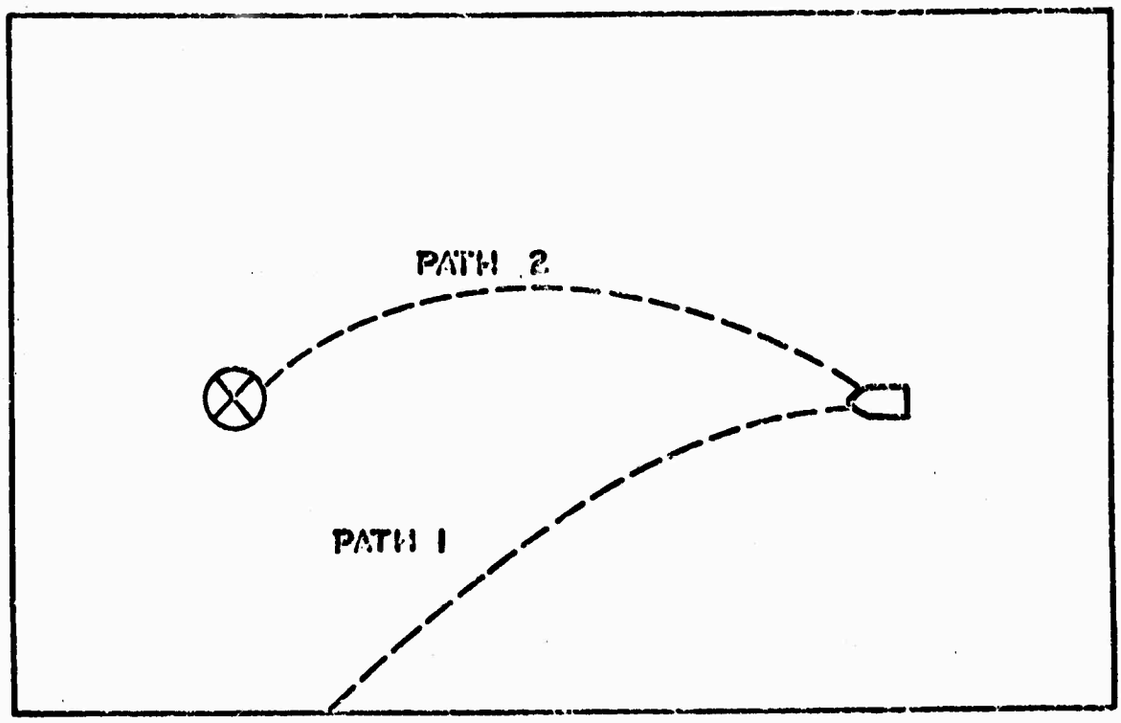


Figure 3b

TASK DESCRIPTION #5

The subjects for this experiment were four experienced pilots with various amounts of helicopter experience. The vehicle used was a Hiller model 12-E, similar to the Army's standard primary training helicopter but with an engine of higher horsepower.

The task chosen for the study was a series of four power line patrol missions over terrain unfamiliar to the subjects. Eight flight routes were chosen, each of which required approximately two hours for completion; pilots flew two routes on each experimental day.

Each pilot flew the routes in identical order. After driving to or being flown to a starting point, subjects were given a map showing rural electric power distribution lines, roads and certain other terrain details. A particular line segment, usually about 30 miles in length, was marked in color on the map. The pilot was required to take off, locate the beginning of the line segment to be patrolled, then to fly at slow speed along the line, looking for damaged cross bars, broken insulators or other sources of potential power interruption.

At a point unknown to the subject in advance, the safety pilot who acted as observer pointed out a tap, or terminal distribution line, to the subject, who was required to turn off the mainline and inspect the tap to its end. The subject then pulled up from the line, returned at higher speed to the main line he had left and continued his patrol. Another tap was pointed out during the second hour of flight, again without prior warning.

When the subject completed his first route he proceeded to a nearby airport, landed and refueled. During approximately twenty minutes on the ground he studied his next flight route. After takeoff he again had to find a line, patrol it and inspect another two taps not marked on his map.

The entire flight (except the return from the end of each tap to the line from which it emanated) was conducted at altitudes of from 20 to 50 feet and at lateral distances from the power lines of from 20 to 60 feet. Pilots had to watch for and avoid crossing cables and high tension lines, as well as livestock which are apt to stampede when frightened by helicopters. The power line maps used were unfamiliar to the subjects, as was the terrain. The task thus incorporated a navigation and detailed reconnaisance function, together with intermittent hazards which had to be avoided.

The helicopter was instrumented to allow monitoring of rotor RPM and of the positions of three controls: the collective pitch lever, the throttle, and the cyclic pitch control stick. The collective pitch lever is used to control the pitch on <u>all</u> blades of the rotor, to allow the helicopter to move in an up or down direction. The throttle of the same type as on a motorcycle, is located near the top part of the lever. It provides the power for the engine. In order to lift off, the pilot, using his left hand, pushes the lever forward to increase the pitch while at the same time, he presses on the throttle to provide the necessary power. The cyclic pitch control stick is used to control the pitch of each blade individually, to allow the helicopter to move in any direction other than up or down. The stick is operated with the right hand.

As noted, each subject flew the four missions in the same order. The first and second days of flying were in relatively hilly terrian, whereas the third and fourth days were over generally flat farmland.

The dot on the left represents the target vehicle. At the start of each rendezvous maneuver the interceptor will be 80,000 feet ahead and 20,000 feet above the target. The scale on the display is 1 inch = 10,000 feet. The task is to rendezvous with the target within 15 minutes using as little fuel as possible.

At the beginning of each run the initial impulse of a two-impulse transfer has been initiated but not so the subject will coast along the best trajectory. The subject is to correct the orbital path with this controller and continue to "fly" to the target and stop the interceptor at the target. In order to accelerate the interceptor in a specific direction, the subject displaces the control stick in that same direction. The more the stick is displaced the more thrust that is applied. To aid the subject in stopping at the target the scale is expanded when the interceptor gets close to the target. When a range of 10,000 feet is reached (1 inch from the target) the scale will be expanded to 1 inch = 1,000 feet.

The interceptor is to be flown to the target, until the dots touch; then the subject stops the interceptor. He is to use as little fuel as possible and make his rendezvous within 15 minutes.

TASK DESCRIPTION #6

Bill, a 21 year old senior, plays basketball for Artichoke University. He is team captain and plays center since he is the tallest man on the team. During the last game he scored 34 points and got 17 rebounds. Parts of the game went as follows: On the opening jump, Bill tapped the ball to one of his team-mates, they ran down the court and Bill was fouled in the process of shooting. Bill made both of his foul shots. The other team took the ball out of bounds and passed back and forth to each other looking for a good shot. Bill anticipated one of the passes and lunged for the ball which he knocked out of bounds. After the other team scored, there was a fast break and Bill dribbled down the length of the court. He faked out two opponents and went in for the lay-up.

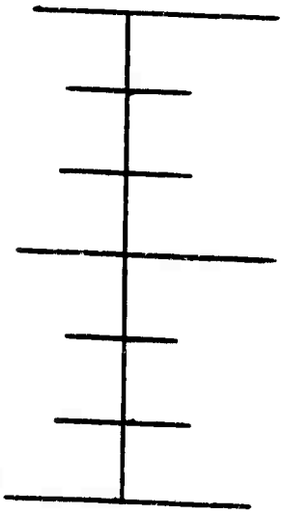
There were very few fouls in the first quarter and the players were constantly on the run.

ANSWER SHEET

Task Description Number _____

ABILITY #____

HIGH

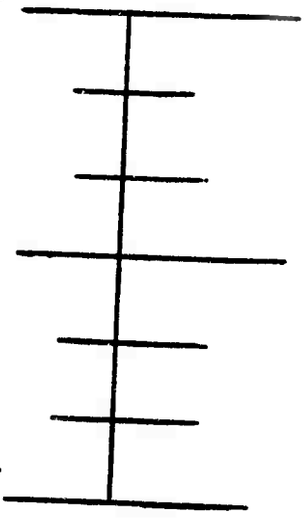


LOW

☐ DOES NOT APPLY

ABILITY #____

HIGH



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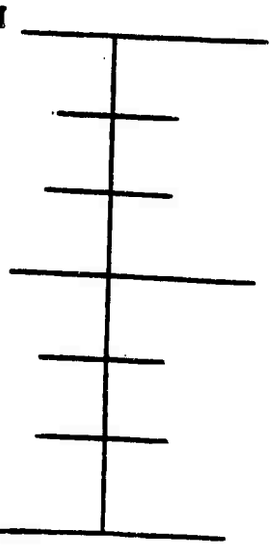
ABILITY #____

HIGH



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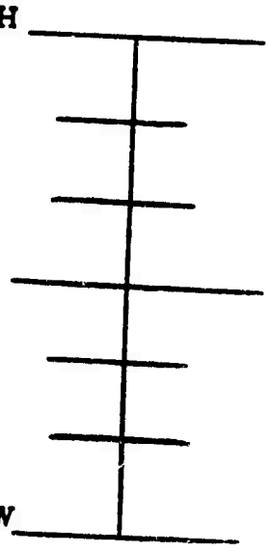
☐ DOES NOT APPLY

ABILITY #____

HIGH



LOW

☐ DOES NOT APPLY

TASK DESCRIPTION RATING SCALES

1. Degree to which you understood the task description

Very Poor
Completely unable to understand the task and what it requires of the subject.

Fair
Understanding

Thoroughly Understood
Including complete comprehension of all of the details.

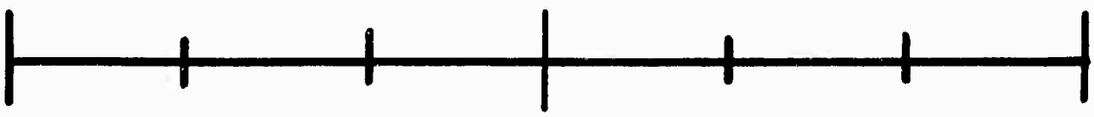
2. Completeness of Task Description

Very Poor
Not enough detail provided to make meaningful ratings of the task or to permit comprehension of the task.

Fairly
Complete

Very Complete
All necessary detail provided for full comprehension of the task.

3. Clarity of Task Description



Very Poor
Description of task confusing and difficult to follow. Terminology imprecise or ambiguous.

Fairly Clear

Extremely Clear
Task description is very lucid and easy to follow. All terminology is precise and unambiguous.

4. Degree of Familiarity with the task

Not at all
Know no more about the task than is presented in the task description

Fairly Familiar

Thoroughly familiar
Know all about the basic including all of the details

5. Source of Familiarity
(Check one or more)

Reading /__/

Have seen others perform the task /__/

Have performed the task personally /__/

6. Degree of personal experience in performing the task

None at all
Have never attempted the task

Fairly experienced

Thoroughly experienced
Have performed the task on very many occasions

7. If you have experience on the task

Degree of proficiency on the task

Not at all Proficient
Can perform the task only at an extremely low level

Fairly proficient

Highly proficient
Performance on the task is essentially perfect

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

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George C. Theologus, Tania Romashko, Edwin A. Fleishman

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13. ABSTRACT

A major problem which confronts the behavioral sciences is the lack of a unifying set of dimensions for describing human task performance. The absence of such a system limits the ability to relate human performance observed in one task to that observed in similar tasks. There is a need for a well-defined task-descriptive language for use by those who must apply the results of research to operational tasks. This report describes one of several approaches under development as part of a larger program; the approach is concerned with developing a task classification system based upon known parameters of human performance. The human abilities, upon which this system was based, were derived primarily from the reported factor analyses of human performance in the cognitive, psychomotor, physical, perceptual, and sensory areas. Definitions of the abilities were developed together with rating scales for each ability. A series of pilot studies then were undertaken with the objective of producing an instrument which would have high reliability in classifying human tasks. During these exploratory studies, the initial set of human abilities was modified, the definitions of the abilities were revised, and the rating technique was improved upon. In addition, the studies examined various methods of analyzing the reliability data, and compared two methods of anchoring the rating scales. The results of this pilot research indicated that it was possible to develop a set of reliable, ability-based scales for

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13. Abstract (Continued)

classifying tasks, although more work will be needed. Future research on a human ability approach to classification will continue with the investigation of the problems of scale reliability and will initiate research on questions of the validity of the classificatory instrument.

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